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A WORKING DOCUMENT FOR AIR POLLUTION MEASUREMENT TECHNIQUE DEVELOPMENT

FISCAL YEARS 1972-1977

ESSO RESEARCH AND ENGINEERING CO.

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

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December, 1971

for
Office of Program Development
Office of Air Programs
ENVIRONMENTAL PROTECTION AGENCY
Rockville, Maryland

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The report presents, in detail, a research, development, test and evaluation plan for the Environmental Protection Agency, covering the fiscal years 1972 through 1977. The plan will provide for development of air pollution measurement techniques: to support EPA research and investigations into the causes, effects and extent of air pollution; to identify and quantify air pollutants; to assist in the setting of standards and to determine compliance with standards; and to support a continuing EPA effort to maintain adequate measurement capabilities.

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FOREWORD

The important role played by measurement techniques in meeting the legal commitments imposed by the Air Quality Amendments of 1970 requires an integrated and far reaching research,development, test and evaluation plan. The Environmental Protection Agency which has the primary responsibility for the effort, undertook the development of this plan. The Office of Program Development (OPD) in the Office of Air Programs (OAP) initiated the development of the integrated plan in 1969 by negotiating a contract with Esso Research and Engineering Company (Esso) to act as an extension of the EPA in-house capability in the study.

The development of the plan involved a dynamic interplay between the contractor and EPA personnel which led first to a recognition and assessment of the measurement capabilities required to meet the legal commitments imposed by the new air pollution control legislation and later to a plan to achieve these capabilities. Some 90 individuals within EPA contributed to development of the plan through the coordinating efforts of the Division of Chemistry and Physics (DCP), the lead EPA organization charged with developing air pollution measurement capabilities.

This document is a formal report of the findings and conclusions developed during the two years of this study; many of the results themselves having been already integrated into the DCP program plans for 1972-1977 during the last EPA planning cycle. This document is intended as a working document, reflecting a current assessment of the measurement needs and a plan to meet these needs. It is anticipated that this plan will require continuous updating to reflect new findings and the availability of the implementing resources.

This document was prepared for EPA by Esso Research and Engineering Company under the direction of Drs. Robert S. Kirk (OPD), Alfred H. Ellison (DCP) and Rene R. Bertrand (Esso). Participants from Esso included Messrs. H. J. Hall, N. L. Morrow, R. H. Salvesen, R. A. Brown, W. H. King, Jr. and G. M. Varga, Jr. The final copy prepared by Esso reflects the opinions and comments of EPA. The major portion of the summary was prepared by Dr. R. S. Kirk of EPA (OPD).

SUMMARY

The following is a comprehensive summary of the working document for air pollution measurement technique development for fiscal years 1972 through 1977. It is written to give the reader, in briefest fashion, a comprehensive idea of the scope of the development program defined in the working document and the specific tasks required to carry it out. The reader is referred to the supplementary working document for complete details. The summary is organized in the same manner as the working document for easy reference and is outlined as follows:

Part 1 - Introduction, Background and Scope

Part 2 - Measurement Capabilities Required

Part 3 - Research and Development Needs

1. Structure of the Task Statements
2. Measurement Techniques to Support EPA Research and Investigations
3. Measurement Techniques to Identify and Quantitate Air Pollutants
    - 3.1 Ambient Air Quality Measurements
    - 3.2 Stationary Source Emission Measurements
    - 3.3 Moving Source Emission Measurements
4. Techniques to Support EPA Programs to Maintain Adequate Measurement Capabilities
5. Resources Required
    - 5.1 Consolidation of Funding Requirements on Task Statements
    - 5.2 Funding for Replacement and/or Improvement of Measurement Methods
    - 5.3 Funding for Future Requirements
    - 5.4 Funding Summary
    - 5.5 Manpower Required

Part 1 - Introduction, Background and Scope

The Clean Air Act of 1967 authorized development of instrumental and analytical methods required to meet the legal obligations that have been or will be set. Only a portion of the requirements of the original act plus those specified in the Amendments of 1970 can be fulfilled with currently available measurement techniques. A recent survey indicated private industry does not have adequate incentives to develop many of the required techniques. Therefore, it is necessary for the Federal Government to fund research and development to assure the availability of adequate instrumentation and methodology.

The scope of this EPA plan is broad but not all inclusive. It does include the development of the following:

1. Measurement techniques for identification and quantification of air pollutants to assist in the setting of standards and to determine compliance with the standards.
2. Measurement techniques to support EPA research and investigations into the causes and extent of air pollution.
3. Measurement techniques to support EPA studies on effects of air pollution.
4. Test procedures to support programs for determining equivalency of new measurement techniques.
5. Test procedures, test samples and calibrated gases required for quality control programs.

However, it does not include the following which are, in most cases, the subject of other EPA investigations:

1. Determining where to sample emission sources to obtain representative emissions.
2. Determining how to simulate representative emissions from moving sources.
3. Measuring the effects of pollutant exposure level on the health of individuals.
4. Measurement techniques for support of programs to develop air pollution control technology (one of a kind methods).
5. Measurement techniques required during air pollution episodes. (The techniques included in this report will probably be adequate to accommodate most such episodes.)

6. Development and implementation of actual quality control and equivalency determination programs.

7. Measurement techniques for pesticides or radiation control.

Both manual and automated instrumental methods are included where appropriate for most of the test requirements. The manual method is a technique suitable for intermittent measurements and requires the presence of an operator. The automated instrumental method is intended to permit unattended measurement of the particular pollutant desired and should be suitable for monitoring purposes.

Part 2 - Measurement Capabilities Required

The Clean Air Amendments of 1970 imposed a number of requirements on Federal, state and local governments as well as private organizations. Analyses of these requirements and of the EPA promulgations issued to date indicate measurement requirements in the following areas:

1. To support research and investigations relating to causes, effects and extent of air pollution.

2. To identify and quantitate data on air quality and source emissions to assist in the setting of standards and to determine if pollution levels comply with the standards.

3. To support the continuing program to maintain adequate measurement capability required by the nation's air pollution control program.

The analysis of requirements for each of these areas is treated in separate sections of the report.

Within the research and investigations section, development needs are aimed at personnel exposure level dosimeters and economic effects measurement packages. In addition, the section covers the requirements for remote and long-path measurement of air pollutants.

Measurement capabilities required to identify and quantitative air pollutants are needed in 3 general areas: ambient air quality, stationary source emissions, and mobile source emissions. Ambient air measurements are tied to National Ambient Air Quality Standards (NAAQS) and National Emissions Standards for Hazardous Air Pollutants (NESHAP). Pollutants already covered under NAAQS are sulfur dioxide, particulates, nitrogen dioxide, carbon monoxide, non-methane hydrocarbons and oxidants. NESHAP's are discussed below. Measurements required are of two distinct types; a 24-hour sample of the pollution level conducted at 6 to 14 day intervals, and a continuous measurement.

The emissions from stationary sources of air pollution will be controlled under: (1) New source performance standards (NSPS); (2) NESHAP; and (3) Implementation plans to achieve National Air Quality Standards. If the pollutant covered by NSPS is not covered by NAAQS, the amendments of 1970 require that the states establish similar standards for existing plants. At the time of writing this report, standards of performance for new stationary sources have been issued for 5 industry sources and standards have been established for the emissions of particulates, sulfur dioxide, sulfuric acid, and nitrogen oxides. Three pollutants have been designated as hazardous air pollutants - beryllium, asbestos, and mercury. Depending upon the specific case of pollutants and industry, the measurements required are the manual and automated instrumental method and in addition an automated portable measurement device for spot checking.

The moving source emission measurement requirements deal mainly with automobiles. Also included are gasoline fueled light and heavy duty engines, heavy duty diesel engines, aircraft, and other newer power sources such as heavy duty turbines for motor vehicles. In addition, there are measurement techniques required for a fuel registration regulation program. Due to characteristics of the emissions of mobile sources while in use, it is necessary to establish a test cycle in addition to procedures and methods for analysis of the emissions.

Section 202 of the clean air amendments establishes automobile emission standards for 3 air pollutants - carbon monoxide, hydrocarbons, and oxides of nitrogen. It further specifies that the measurement techniques on which such standards are based shall be prescribed by regulations. There are requirements to measure emissions from new motor vehicles as well as vehicles in general use. Section 206 of the legislation covers new motor vehicles and motor vehicle engines. This type of testing is normally referred to as certification or compliance testing and the administrator shall by regulation establish methods and procedures for making the tests required. Testing of vehicle engines in actual use is covered in Section 207 which gives the administrator the authority to establish methods and procedures and check motor vehicles in use, and in Section 110 which requires that the state provide in implementation plans a program to the extent necessary and practical for the periodic testing and inspection of motor vehicles to enforce compliance with applicable emission standards. These programs require the measurement capability to conduct emission testing of vehicles in general use.

Section 231 of this legislation provides for aircraft emission standards. They have not been issued at the time of writing this report. Section 211 provides for regulation of fuels and fuel additives, and this may require analytical techniques that can be used to test and measure additives in fuels and to determine emissions which result from the use of such fuels.

Available plans of the EPA have been considered so that new measurement requirements could be anticipated. Source categories for new source performance standards and a schedule for promulgation as well as for the pollutants which standards are to cover have been estimated for the purposes of this plan and are listed by five groups of industries. Listings and future dates of standard promulgation represent estimates to enable scheduling of measurement requirements, and must not be construed as rigid at this writing; they are subject to change. The industries covered by the various groups are listed below.

Group I - Steam generators greater than 25MW, cement plants, municipal incinerators, sulfuric acid plants and nitric acid plants. (Performance standards promulgated on December 23, 1971.)

Group II - Asphalt batch plants, petroleum refineries, rendering plants, steam generators, (25 MW and less) brass and bronze refining, iron and steel mills, sewage treatment plants, secondary lead smelters. (Promulgation date estimated July 1, 1972.)

Group III - Copper smelters, lead smelters, zinc smelters, aluminum reduction plants, pulp and paper mills, coke plants, phosphate fertilizer plants, phosphorus reduction plants, animal feed defluorination plants, ferro-alloy plants and coal cleaning plants. (Promulgation date March 1, 1973.)

Group IV - Petrochemical plants, grey iron foundries, sulfur recovery units, gas turbines, lime plants, grain milling and handling, hydrochloric acid plants, phosphoric acid plants, paint and varnish, and graphic art plants. (Promulgation date November 1, 1973.)

Group V - Soap and detergent manufacturers, cotton gins, auto assembly plants, chlorine and caustic plants, rendering plants, sewage treatment plants, and additional iron and steel plants and petroleum refineries. (Promulgation date July 1, 1974).

Additional moving and stationary source emission standards have been anticipated for the purposes of this R/D plan to cover odor, fine particulates, aldehydes, reactive organics, rubber and asbestos.

Two EPA programs have been identified which will require measurement support to assure the maintenance of adequate measurement capabilities. They are: (1) equivalency determination and (2) quality control. The development and implementation of these programs is outside the scope of this plan but the measurement techniques in support of them are provided for in the plan. Techniques necessary to conduct equivalency determinations must yet be established and this plan provides for the development of methods, procedures, and standards required. The quality control program must provide the capability for routine calibration of measurement methods which are in general use, and must also provide for a periodic evaluation of user competence. This plan provides for the development of measurement methodology and materials required to support the quality control program. It does not include the supply of such materials for implementation of the program.

A detailed matrix chart presenting a summary of the development requirements has been prepared for the working document, to serve as an overall status check and guide for future work specified by this RDT&E plan. A brief version of this matrix is enclosed in the summary below. The matrix chart in the summary shows by a dot at the intersection of the source and pollutant where test method development is required. The matrix chart lists the pollutants, source of the pollutants and the measurement needs. The more detailed matrix in the working document indicates the tasks by number which are necessary to satisfy the requirements.

Part 3 - Research and Development Needs

This section of the report gives in detail the work tasks which are required to comply with the air pollution measurement technique development plan. The rationale for each task is given along with a brief background on the current state of the art where appropriate and a brief summary of what is involved in the actual task to be accomplished.

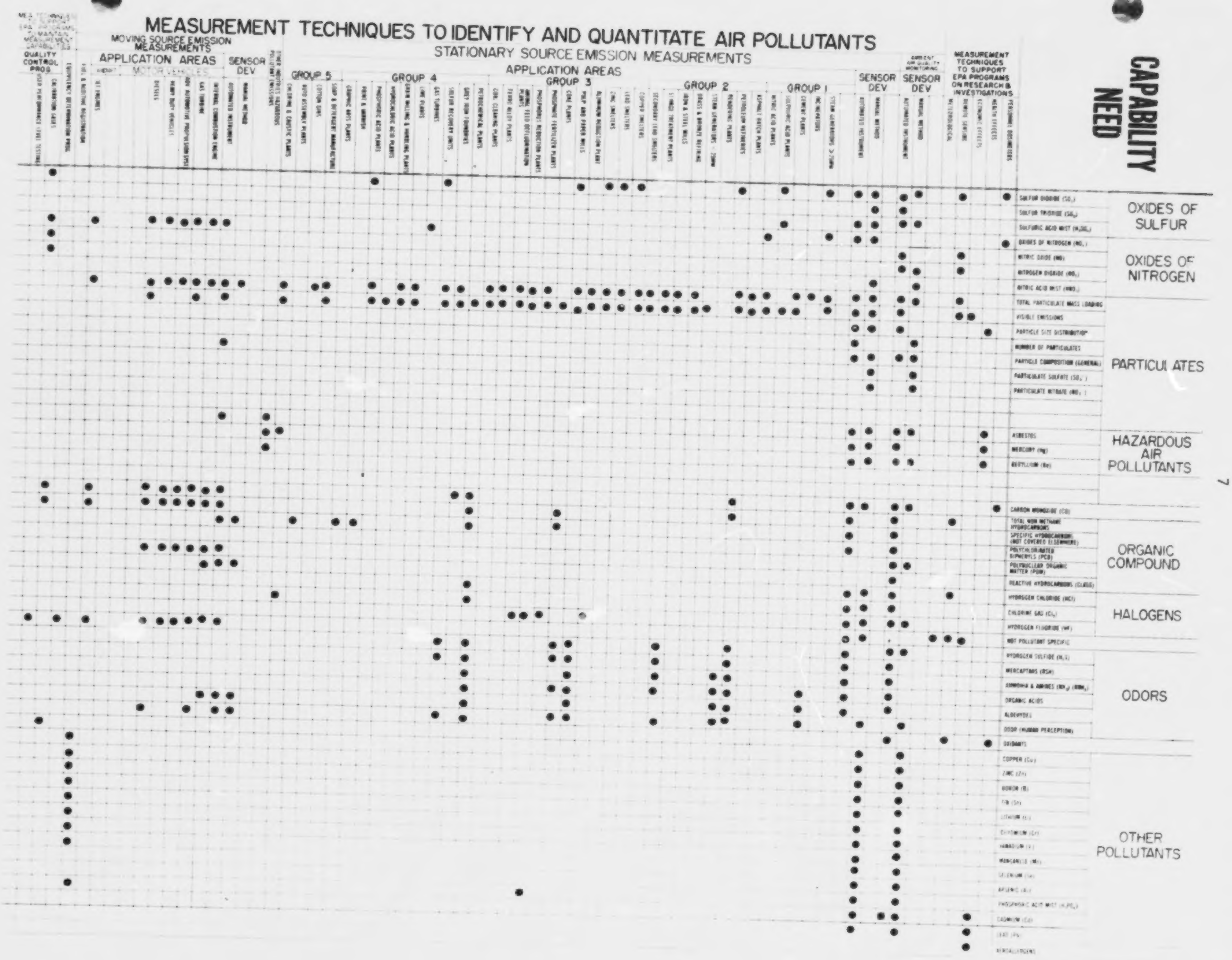
1. Structure of the Task Statements

Task statements are assigned wherever work needs to be done. The task statement gives information of the following type: (1) a brief description of the work required, (2) cost and time estimates required for completion of the task, and (3) a list of critical milestone dates for compliance with EPA needs. The work categories are defined as research, development, field testing, evaluation and promulgation. If a task starts out with research, it is automatically implied that the other work required will have to be done such as development, field testing, and evaluation before this particular task can be promulgated. If a task starts out with evaluation program, it means that the research development and the field testing have already been done and generally need not be repeated for these requirements.

As noted above, the work activity may start at any one of five levels. Research includes basic research on new measurement concepts and analytical methods. It is anticipated that much of this activity may be done under grants in academic institutions, however, it can be done in government or industrial laboratories. Development activity provides a prototype analytical method which would generally be the culmination of laboratory work done under the research activity. Field testing would follow the development work and it would be anticipated that much of the initial field work would be carried out by or under the close supervision of the individuals who are responsible for the development of the particular technique. Evluation is intended to determine the actual performance of the measurement technique in the hands of the intended final users. Such an evaluation would probably be run at selected locations by the people who will eventually use this equipment.

MEASUREMENT TECHNIQUES TO IDENTIFY AND QUANTITATE AIR POLLUTANTS

CAPABILITY NEED



MEASUREMENT TECHNIQUES TO SUPPORT EPA PROGRAMS ON RESEARCH & INVESTIGATIONS
- PERSONNEL DOSIMETERS
- HEALTH EFFECTS
- ECONOMIC EFFECTS
- REMOTE SENSING
- METEOROLOGICAL

AMBIENT AIR QUALITY MONITORING — SENSOR DEV
- MANUAL METHOD
- AUTOMATED INSTRUMENT

STATIONARY SOURCE EMISSION MEASUREMENTS

SENSOR DEV
- MANUAL METHOD
- AUTOMATED INSTRUMENT

APPLICATION AREAS

GROUP 1
- STEAM GENERATORS > 25MW
- INCINERATORS
- CEMENT PLANTS
- SULPHURIC ACID PLANTS
- NITRIC ACID PLANTS
- ASPHALT BATCH PLANTS
- PETROLEUM REFINERIES

GROUP 2
- RENDERING PLANTS
- STEAM GENERATORS - 25MW
- BRASS & BRONZE REFINING
- IRON & STEEL MILLS
- SEWAGE TREATMENT PLANTS
- SECONDARY LEAD SMELTERS

GROUP 3
- COPPER SMELTERS
- LEAD SMELTERS
- ZINC SMELTERS
- ALUMINUM REDUCTION PLANT
- PULP AND PAPER MILLS
- COKE PLANTS
- PHOSPHATE FERTILIZER PLANTS
- PHOSPHORUS REDUCTION PLANTS
- ANIMAL FEED DEFLUORINATION PLANTS
- FERRO ALLOY PLANTS
- COAL CLEANING PLANTS

GROUP 4
- PETROCHEMICAL PLANTS
- GREY IRON FOUNDRIES
- SULFUR RECOVERY UNITS
- GAS TURBINES
- LIME PLANTS
- GRAIN MILLING & HANDLING PLANTS
- HYDROCHLORIC ACID PLANTS
- PHOSPHORIC ACID PLANTS
- PAINT & VARNISH

GROUP 5
- GRAPHIC ARTS PLANTS
- SOAP & DETERGENT MANUFACTURE
- COTTON GINS
- AUTO ASSEMBLY PLANTS
- CHLORINE & CAUSTIC PLANTS

OTHER INDUSTRIES HAZARDOUS POLLUTANT EMISSIONS

MOVING SOURCE EMISSION MEASUREMENTS

SENSOR DEV
- MANUAL METHOD
- AUTOMATED INSTRUMENT

APPLICATION AREAS

MOTOR VEHICLES
- INTERNAL COMBUSTION ENGINE
- GAS TURBINE
- ADV AUTOMOTIVE PROPULSION SYST
- HEAVY DUTY VEHICLES
- DIESELS

AIRCRAFT
- JET ENGINES

- FUEL & ADDITIVE REGISTRATION

MEAS. TECHNIQUES TO SUPPORT EPA PROGRAMS TO MAINTAIN MEASUREMENT CAPABILITIES

QUALITY CONTROL PROG
- EQUIVALENCY DETERMINATION PROG
- CALIBRATION GASES
- USER PERFORMANCE (VVEL) TESTING

OXIDES OF SULFUR
- SULFUR DIOXIDE (SO_2)
- SULFUR TRIOXIDE (SO_3)
- SULFURIC ACID MIST (H_2SO_4)

OXIDES OF NITROGEN
- OXIDES OF NITROGEN (NO_x)
- NITRIC OXIDE (NO)
- NITROGEN DIOXIDE (NO_2)
- NITRIC ACID MIST (HNO_3)

PARTICULATES
- TOTAL PARTICULATE MASS LOADING
- VISIBLE EMISSIONS
- PARTICLE SIZE DISTRIBUTION
- NUMBER OF PARTICULATES
- PARTICLE COMPOSITION (GENERAL)
- PARTICULATE SULFATE (SO_4)
- PARTICULATE NITRATE (NO_3)

HAZARDOUS AIR POLLUTANTS
- ASBESTOS
- MERCURY (Hg)
- BERYLLIUM (Be)

- CARBON MONOXIDE (CO)

ORGANIC COMPOUND
- TOTAL NON METHANE HYDROCARBONS
- SPECIFIC HYDROCARBONS (NOT COVERED ELSEWHERE)
- POLYCHLORINATED BIPHENYLS (PCB)
- POLYNUCLEAR ORGANIC MATTER (POM)
- REACTIVE HYDROCARBONS (CLASS)

HALOGENS
- HYDROGEN CHLORIDE (HCl)
- CHLORINE GAS (Cl_2)
- HYDROGEN FLUORIDE (HF)

- NOT POLLUTANT SPECIFIC

ODORS
- HYDROGEN SULFIDE (H_2S)
- MERCAPTANS (RSH)
- AMMONIA & AMINES (NH_3) (RNH_2)
- ORGANIC ACIDS
- ALDEHYDES
- ODOR (HUMAN PERCEPTION)

- OXIDANTS

OTHER POLLUTANTS
- COPPER (Cu)
- ZINC (Zn)
- BORON (B)
- TIN (Sn)
- LITHIUM (Li)
- CHROMIUM (Cr)
- VANADIUM (V)
- MANGANESE (Mn)
- SELENIUM (Se)
- ARSENIC (As)
- PHOSPHORIC ACID MIST (H_3PO_4)
- CADMIUM (Cd)
- LEAD (Pb)
- AEROALLERGENS

An analysis of the test results would be required to determine limits of accuracy and reproducibility. The final activity is promulgation of a measurement technique which requires a review, adjustments in the methods which may be required, and finally, publication as an official measurement method in the Federal Register.

Funding required to accomplish the task is listed on each task sheet. Manpower requirements are not included but are discussed in other sections of this report. Funding is specific only for the individual task. The funds required for each specific activity over the time period required to complete the task are given. Contingency funding to cover unexpected difficulties in the test method development is not included on each task but a general contingency fund is discussed in a later separate section of the report.

In the detailed working document, time schedules for completion of the tasks if carried out as planned have been indicated by one or more of three milestones. The first milestone is the estimated date at which the method would be needed for promulgation of a standard. In most cases this has been assumed to be about 9 months prior to the standard promulgation date, to leave about 6 months for measurement activity antecedent to proposing the standard and a 3 month period for comment on the proposed standard. It is assumed that an automated instrumental method will not be required for at least 18 months following promulgation of the standard. The second milestone listed is the expected date on which an interim measurement technique would be available. The third and last milestone indicated is the date on which a fully evaluated measurement technique is expected to be ready for proposal as an official EPA measurement method.

2. Measurement Techniques to Support EPA Research and Investigations

Research and investigation programs of the EPA on the effects and extent of air pollution health and welfare are covered in this section of the report. These aspects of air pollution receive special emphasis in the Clean Air Amendments of 1970. The health effects research requires tasks to develop dosage monitors for personnel (similar to radiation dosimeters) to measure cumulative dosages of specific pollutants. The health effects research studies will require the measurement of different pollutants or the measurement of the same pollutants in many cases in a different manner from that required in the Ambient Air Quality Monitoring Program. The development of the required techniques to perform these measurements is covered below. Personal monitors for pollutants covered by NAAQS such as SO_2, NO_x, CO, and oxidants and also trace metals need to be developed (RI-1)*. Two tasks have been included to develop new measurement techniques for aeroallergens, a natural pollutant, which include development of standard aeroallergen samples and a rapid means of measuring specific aeroallergens (RI-2,3). While many other measurement techniques were identified to support health effects research, they did not involve the identification or quantification of an air pollutant and thus are outside the scope of this plan. However, a listing of 8 different areas for instrumentation development is included in the more detailed working document.

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* Numbers in parenthesis are the numbers assigned in the main text of this report to the task necessary to satisfy the need indicated.

Measurement techniques to determine the long-term effects of air pollution damage to plants and materials, are needed. Techniques suggested are based on the use of an "effects package", which is a selection of materials in a suitable container which can be placed in specific locations to determine the effect of air pollution exposure on the materials (RI-4). While this is the only task described in this section, many of the other measurement techniques described later, especially in the Ambient Air Quality Monitoring section, will be applicable to assessing economic damage of air pollutants.

To support EPA requirements for programs investigating the causes and effects of air pollution, measurement techniques for remote sensing are required. The measurement techniques suggested are intended to survey a broad range of materials to determine overall air quality and to monitor gross effects of pollutants. A study including cost benefit analysis should be run to evaluate the potential of these techniques for more routine application (RI-5). A number of instrumental techniques have been studied. Some are in use to study particulates in, for example, plumes from power generating plants. These techniques have included optical transmission, laser beams, and other techniques which generally depend on particulate density in the area under study. However, further development work is required to develop practical instruments and data interpretation techniques (RI-6,7). Remote sensing of gases has received considerable study, since this method offers a number of advantages over point sampling. Advantages include more representative samples and avoidance of interfacing between an analyzer and the particular source being studied. Electro-optical techniques are fairly well advanced using IR emission and absorption spectroscopy. Convair of San Diego has developed an instrument and delivered this to EPA personnel for field evaluations in the Los Angeles area in the spring of 1971. Additional systems have been developed by Bendix for EPA. Additional grants and contracts have been issued to G.E., Zaromb Research Foundation and the University of Florida for development of improved remote sensing systems. Out of this work should come a practical field instrument for remotely measuring gaseous pollutants emitted from a single source (RI-8) and long path integrated measurement techniques for measuring emissions from area sources (RI-9).

To satisfy the requirements of meteorological measurements, development of additional capabilities are indicated to be needed to study the interaction of dispersant atmospheric forces and pollutants. The measurement techniques anticipated are beyond the currently applied technology. For example, remote sensing of the temperature profile, atmospheric turbulence and wind measurements up to a height of 1500 meters are required (RI-10,11,12,13). These tasks all begin in the development stage but generally will require merely refinement of one of the already developed techniques for meteorological measurements.

3. Measurement Techniques to Identify and Quantitate Air Pollutants

This section covers the tasks required to satisfy the measurement needs of monitoring ambient air levels of stationary and moving source emissions. A total of 122 tasks are included, 49 in the ambient section, 39 in the stationary source section and 34 in the moving source section.

3.1 Ambient Air Quality Measurements

The analytical methods and instruments which will be required to measure the ambient air quality level throughout the United States are considered. Specific requirements are indicated by pollutant classes as noted below.

1. SO_2 and sulfur compounds
2. Particulates
3. Carbon oxides
4. Nitrogen oxides
5. Ozone and oxidants
6. Hydrocarbons
7. Halogens
8. Hazardous air pollutants
9. Other pollutants
10. Odors

An analytical manual method for SO_2 has been listed in the Federal Register of April 30, 1971. However, additional work is required for instrumental methods for continuous analysis of SO_2, as well as cumulative 24-hour sampling and measurements of SO_2 (IQA-1,2). Flame photometric detector techniques look promising for total gaseous sulfur compounds and for specific sulfur containing compounds. Thus, with very little development work and field testing, this method should be ready for approval (IQA-3). A simple method for cumulative H_2S measurements over a period of time less than 1 hour is needed (IQA-4). A manual method for molecular sulfuric acid mists does not exist and needs to be developed (IQA-5).

Current techniques for measuring total particulate mass are primarily based on the high volume filter samples or on collections on tapes for more rapid measurement. These need to be replaced with better techniques employing improved tape samplers or instrumental methods (IQA-6,7).

Development of an improved filter medium is needed before Hi-Vol samplers are completely satisfactory (IQA-8). Other techniques for improved instrumental measurement of cumulative particulate mass loading will need evaluation (IQA-9). Instruments for measurement of particulate size distribution are available for sizes down to 0.1-0.5 micron but they need evaluation and for smaller particle size measurements, new instrumental techniques need to be developed (IQA-10,11). The effect of particulates when fully evaluated should be suitable for instrumental measurement (IQA-12). Composition of collected particulates can generally be measured by emission spectroscopy, atomic absorption, etc., depending on the particular type of material, but additional developmental and evaluation work is required to assure the adequate application of these techniques at concentrations encountered in air pollution studies (IQA-13).

Measurement of CO by NDIR was specified in the Federal Register recently. However, improved methods such as the GC with FID need to be developed to enable more satisfactory measurement of the lower levels of CO (IQA-14). Additional instrumental methods for ambient level CO measurements are anticipated to become available from the private sector and will need evaluation for improved official methods (IQA-15). Research is needed to develop a simple instrumental method for cumulative sampling and measurement of CO (IQA-16).

Measurement of NO_2 by the Jacobs-Hochheiser manual method needs further evaluation (IQA-17), and there is an apparent need for an improved method (IQA-18). Developments in instrumental methods for continuous measurement and cumulative sampling and measurement of NO_2 are required (IQA-19,20). The development of instrumental methods for continuous measurement of NO is nearly complete, and instruments are needed for cumulative sampling and measurements of this material (IQA-21, 22). A method for nitric acid vapor or mist is required (IQA-23).

Total oxidants (TOX) and ozone in ambient air are measured by the KI method as indicated in the Federal Register; this method needs further evaluation for correlation to other methods in use (IQA-24). Many instruments have been offered for measurement of these oxidants in air and need to be evaluated as possible improvements over the KI method (IQA-25). A simple device for cumulative measurement of TOX is needed (IQA-26).

Hydrocarbons of many types including substituted compounds such as alcohols, aldehydes, and esters have been generally lumped together as air pollutants. However, specific tests will be needed to distinguish the various components. The gas chromatograph coupled with FID looks promising but needs further evaluation for total hydrocarbons above methane, and further development for identification of specific components such as PCB (polychlorinated biphenyl) etc. (IQA-27,28). Hydrocarbons which are most active in smog and oxidant forming reactions are a special class and a routine procedure for measuring this class is desired (IQA-29). Instrumental methods for the routine measurement of aldehydes need further development and evaluation (IQA-30). Polycyclic aromatic materials (POM) are of particular concern and some of them have been identified as carcinogens; chief among these is benz-a-pyrene (BaP). Many techniques are available to measure these compounds but there is a need to select the best procedure for analysis of BaP (IQA-31). An automated instrumental method for this material looks promising based on GC techniques (IQA-32). It is anticipated that additional POM compounds may be of particular concern in the future and thus, additional test methods will probably be required for specific carcinogenic compounds (IQA-33).

Halides of concern are generally fluorides and chlorides. These materials may be released from industrial operations, such as aluminum plants, fertilizer plants, etc., as well as from incinerators and coal combustion. Several instrumental methods for HF detection need evaluation to select the most promising technique for this component in the gaseous state (IQA-34). The present indication, which is still to be confirmed, is that a preferred manual method for total particulate fluorides must be developed which includes the determination of both water soluble and insoluble fractions (IQA-35). Many methods are available for measurements of both chlorides and HCl in the atmosphere, and the best instrumental methods need to be field tested (IQA-36).

Hazardous air pollutants include asbestos, mercury and beryllium. Microscopic techniques are generally required to distinguish asbestos from other fibers and established manual techniques need to be evaluated (IQA-37); research is needed for techniques which can measure asbestos by instrumental methods (IQA-38). Mercury is present in various forms in the atmosphere and, due to the toxicity of almost all forms of mercury, detection equipment for its measurements at the ppb level by atomic adsorption or neutron activation techniques need to be developed (IQA-39). Beryllium has been included in the list of hazardous air pollutants. Measurement techniques are fairly well developed for beryllium and field testing of manual wet chemical techniques is required to promulgate an interim method (IQA-40). However, further development is required for an acceptable instrumental technique (IQA-41).

The measurement of lead, which is generally in the form of molecular organic or inorganic compounds can be accomplished by the use of atomic adsorption techniques. Further developments and evaluations are required for an acceptable manual technique (IQA-42). Cadmium in solid particulates may be detected by IQA-13 but both manual and instrumental techniques need to be developed for volatile cadmium compounds (IQA-43,44).

Manual techniques for other pollutants such as volatile compounds of the toxic non-metals, i.e., arsenic, selenium, and phosphorus, and of trace metals are required (IQA-45,46).

Detection of odors currently relies on field tests with human sensors and procedures need to be perfected for conducting these tests (IQA-47). In addition, specific tests are needed for instrumental measurement of specific odorants such as reduced nitrogen compounds and correlation of these measurements with general public response levels (IQA-48,49). Measurement methods for reduced sulfur compounds and for organic acids and aldehydes will be provided by tasks IQA-3,4 and 30.

3.2 Stationary Source Emission Measurements

Permanently fixed facilities that contribute to air pollution are designated as stationary sources. This section covers the research and development tasks required to meet the needs for measurements from these sources. While many industries have been identified in this section, not all the specific industries have been enumerated. Development activity expenditures are considerably less in this section since there is a significant incentive for private industry development. Thus, most of the tasks start out with a field test activity. The major pollutant classes which are covered are (1) sulfur oxides, (2) oxides of nitrogen, (3) total particulate mass loading, (4) visible emissions, (5) other particulate properties, (6) hazardous substances, (7) carbon monoxide, (8) organic compounds, (9) odors, (10) halogens, and (11) other pollutants. A brief description of the measurement techniques required for each of these areas follows.

Satisfactory manual methods do exist for the measurement of total SO_2, sulfate ions, sulfuric acid mist, and SO_3, however, these methods need to be field tested and evaluated (IQS-1). Since SO_2 and sulfuric acid mist are of particular concern, there is a need for continuous monitors of the emission of these pollutants. Many automated continuous monitors for SO_2 are fairly well developed and need evaluation (IQS-2). No monitors are available for sulfuric acid mist and thus development of an automated method is required (IQS-3).

The available manual method for total nitrogen oxides based on a reaction with phenol disulfonic acid (PDS) needs to be evaluated to insure its adequacy and reproducibility in the hands of users (IQS-4). Manual methods are required for particulate nitrate and nitric acid mists to enable emission factor determinations (IQS-5). At least 4 different techniques have been considered for automated analysis and monitoring of NO_x and these are currently being field tested under contract at Monsanto Research Corporation; subsequently, evaluation for an official method will be conducted (IQS-6).

To measure total particulate mass one of the main problems appears to be sampling. It is anticipated that there will be a need for an isokinetic sampling device, and once this is established, a satisfactory automated isokinetic sampling device will have to be perfected (IQS-7). The proposed Federal particulate sampling method requires prior cooling of the effluent gases before their collection, and since this is somewhat different from some of the various methods used by different agencies, the importance of full evaluation of the Federal method is stressed (IQS-8). A constant volume sampling method of determining total particulate mass from stationary sources with appropriate dilution to represent effluent gases from the stack should be developed (IQS-9). Available devices and promising concepts for automated methods are currently being evaluated under an EPA contract with Thermosystems, Inc. Two techniques look best at present: the piezoelectric crystal detector and the use of beta guaging. Based upon this evaluation, the most promising concepts will be developed and/or evaluated (IQS-10).

A manual method for the determination of white smokes needs promulgation (IQS-11). Automated instruments based on light extinction devices look promising and need further development and evaluation, and also need to be correlated to the opacity measurement obtained by human observations (IQS-12).

Other particulate properties such as particle size, number of particles and particle composition need further test method development work. Particle size can be determined by available devices (i.e., Anderson or Brinks sampler), but new techniques need to be developed for a manual method for determining particle size distribution in the range of .05 to .5 microns (IQS-13). EPA currently has a contract with Environmental Research Corporation for the development of an automated sampler analyzer for particle size distribution (IQS-14). Available instrumental techniques employing optical detection methods appear promising for use as instrumental techniques to sample and analyze for the number of particles in a gas sample and need evaluation (IQS-15). Particle composition may become a requirement in future standards. The Naval Research Laboratory currently has a contract with EPA which should lead to an on-stream analyzer for measurement of the composition of particulate matter (IQS-16).

Analytical manual methods for the determination of hazardous substances such as asbestos, mercury, and beryllium are well known. However, they have not been fully evaluated for use in testing emissions from stationary sources (IQS-17, 18, 19). Automated instruments for measuring mercury are fairly well developed and need evaluation; however, development work needs to be done on a similar method for asbestos and beryllium (IQS-20, 21, 22).

Commercial instruments for the determination of carbon monoxide need to be evaluated for manual and automated measurement (IQS-23).

Total gaseous (non-methane) hydrocarbons may be readily detected by use of non-dispersive infrared or flame ionization techniques. However, these commercial techniques have limitations and need complete evaluation and for more specific differentation of the composition other instruments (i.e., GC with specific detectors) need to be developed and evaluated (IQS-24, 25).

The major odors from stationary source emissions are hydrogen sulfide, total reduced sulfur, amines, organics, acids and aldehydes. Odor levels not specific to particular compounds are best determined by human odor panels, and the evaluation of this technique is included in IQA-47. For sources which generate mainly sulfur based odorants, gas chromatographic columns may be used for separation followed by flame photometric detectors. Currently available instruments need to be evaluated to determine their suitability for stationary source emission measurement (IQS-26). Similarly, GC techniques followed by more specific detection equipment may be used to determine odorants based on ammonia, amines, organic acids and aldehydes and need evaluation or development as determined required from evaluation studies (IQS-27, 28). Gaseous effluents from many different plants have not been identified thoroughly enough and this must be done in order to develop test method progress (IQS-29).

Manual methods for halogens are generally based on colorimetric or gravimetric methods, and these need to be further tested and evaluated for gaseous stationary source emissions (IQS-30,31). Automated techniques for fluorine based on colorimetric or ion electrode and for chlorides based on ultraviolet absorption or ion electrode analyzers need further field testing and evaluation (IQS-32,33).

Cadmium and lead are currently of special significance and manual methods for their measurement must be developed and more fully evaluated (IQS-34,35). Additional pollutants which are of concern at present include gaseous compounds of arsenic, selenium and phosphorus. It is necessary to develop manual methods for these materials and additionally for gaseous compounds of trace metals such as copper, nickel, zinc, boron, tin, lithium, chromium, vanadium, and manganese so that at least emission factors can be determined and ambient air quality levels predicted (IQS-36,37). Automated instruments for the detection of cadmium and other materials have not been included in the DRT&E plan but may be required. In order to obtain mass emission rates needed to set standards and to determine compliance with the standards data on mass flow velocity, temperature and pressure from stacks will be required; techniques for temperature and velocity profile measurement must be developed (IQS-38,39).

3.3 Moving Source Emission Measurements

Three areas of concern are discussed in this section: (1) Motor vehicles, (2) Aircraft, and (3) Fuel registration programs. Most of the measurement techniques required are covered in the motor vehicle emissions section, since many of these tests will also apply to emissions from aircraft, and also to the fuel registration program.

Of special concern in test development of motor vehicle emissions is sampling to assure measurement of meaningful emissions. The operating cycle under which motor vehicles are to be evaluated has already been specified by Federal regulations. Sampling under these operating conditions presents a problem because of the different volumes of exhaust emissions which may be emitted depending upon the vehicle operating conditions. For example, the oxides of nitrogen emissions may range between 5 and 4,000 parts per million in the exhaust depending on whether the vehicle is in a deceleration or acceleration mode. Collection of the total exhaust emission is not practical nor is it practical to sample only a small portion since the exhaust composition is known to vary over this cycle. Thus, it is necessary to develop a simplified exhaust flow and/or carburetor air intake sensor to control proportionating volumes when sampling raw exhaust (IQM-1). Currently, EPA regulations required a constant mass sampler (CMS). This CMS system does appear practical for on-the-road use if it can be reduced in size and, thus, it should undergo development for simplification, then evaluation for on-the-road use (IQM-2). The present plans anticipate that fine particulate (below 2μ) mobile source emission standards may be required about 1975. Consequently, this requires development of adequate sampling procedures (IQM-3). Sampling procedures for other vehicles such as heavy duty gasoline powered engines, heavy duty diesel engines and automotive gas turbine engines also need to be developed (IQM-4,5,6). It is anticipated that new power plants will be forthcoming and thus sampling procedures for such power plants will be required (IQM-7).

Additional air pollutants from motor vehicles during operation are being considered, among them asbestos particles from brakes and rubber particles from tire wear. Thus, additional sampling procedures need to be developed for such materials (IQM-8,9). Additional sampling procedures need to be developed for evaluation of automotive emissions other than on the road, or under the conditions of the Federal test cycle, such as, at the end of the line in production plants, in state motor vehicle inspection stations for spot checking, and in service stations and repair facilities. Different and simplified techniques need to be developed for these requirements (IQM-10,11,12,13). Gaseous pollutants emitted from mobile sources now covered by emission standards include hydrocarbons, carbon monoxide and oxides of nitrogen. Additional materials such as particulates, fine particulates, reactive hydrocarbons, heavy hydrocarbons, oxygenates, polycyclic organic matter and odors are additional materials which are anticipated to be covered by emission standards later in the decade. Techniques similar to those which have already been mentioned for these materials need to be developed and adapted specifically for moving vehicle emissions (IQM-14,15,16).

Carbon monoxide levels from moving sources generally are about 1400 parts per million, but the Clean Air Amendments of 1970 specifies a 90 percent reduction by 1975. This is very close to the background level of clean ambient air. The EPA has a fluorescent carbon monoxide sensor under development and this system needs further development and evaluation for measuring carbon monoxide at the lower levels anticipated (IQM-17). Currently available methods for the measurement of nitric oxide based on chemiluminescent reactions with ozone will probably be used to test compliance with Federal emission standards required for 1973 model automobiles. Improved sensors such as those under study by Monsanto Research will be needed for routine monitoring of nitrogen oxide emissions (IQM-18). A need is anticipated for a routine instrument for measurement of polycylic organic matter in the 1976 period. Current analytical methods for polycylic organic matter are satisfactory but instruments need to be developed for routine monitoring of these substances from automobile exhaust (IQM-19). Certain hydrocarbons from auto exhaust are known to be contributors to eye irritation and smog formation. To better define this problem and for control, methods are needed to determine the cause of these responses and to identify the hydrocarbons responsible for them (IQM-20,21). Oxygenated compounds from exhaust have also been identified as reactive species and there is need for a research capability to measure manually such compounds from mobile sources in the first quarter of 1972 and a capability to routinely measure these pollutants by June 1974 (IQM-22,23). Obnoxious odorants emitted from diesel and gas turbine engines need to be characterized and manual and instrumental analytical techniques developed for their measurement from moving sources (IQM-24,25,26).

Adaption of particulate measurement methods based on stationary source requirements are needed for control of such emissions for 1977 model year vehicles (IQM-27). A requirement for routine capability to measure fine particulates has been delineated. This necessitates further characterization work to determine particle size and composition and subsequently to develop a routine instrumental capability (IQM-28,29). Emissions of smoke, especially from diesel and gas turbine engines, can be satisfactorily measured with commercially available equipment, but these instruments need evaluation to determine their acceptability for routine use (IQM-30).

Since most piston aircraft emissions are identical with automotive emissions, automotive sampling procedures are applicable. Thus, the main development requirements are sampling procedures for both gaseous and particulate jet engine exhaust pollutants (IQM-31,32). Analytical techniques developed for hazardous air pollutants and trace metals in ambient air and stationary source emissions should be satisfactory to meet the requirements of the EPA program to register six fuel classes and their additives. It will be necessary to determine if they are acceptable for these programs (IQM-33,34).

4. Techniques to Support EPA Programs to Maintain Adequate Measurement Capabilities

This section of the report describes the measurement development tasks required to support the equivalency determination of new measurement techniques and the quality control program. It is anticipated that new instrumental developments will be forthcoming from industry or other control agencies and these new instruments and measurement techniques must be compared to methods promulgated by the current plan. Thus, there is a need to establish protocols to certify alternate methods and equipment (MP-1). The quality control program must provide the capability for routine calibration of measurement methods which are in general use and must provide for a periodic evaluation of user competence. Tasks to support the quality control program are intended to provide for the development of the standard gas mixtures for calibration and methods for evaluation of performance level of those who use the test methods (MP-2,3). This present plan does not provide the funding or manpower required to run the equivalency determination on the quality control programs.

5. Resources Required

5.1 Consolidation of Funding Requirements on Task Statements

The funding requirement shown on the Task Statements totals over $50 Million over the period fiscal year 1972-1977, with a peak funding requirement of $17 Million in fiscal year 1973.

5.1.1 Funding by Application Areas

A breakout of the funding by application areas is shown in Table 3.1 and is summarized below for the three major application areas.

Application Area	Funding Requirement FY 1972-1977 Millions of Dollars
• Support of EPA Research & Investigation Program	7.04
• Identification & Quantification of Pollutants	41.00
• Support of EPA Maintenance Programs	2.29
	50.33

5.1.2 Funding by Activities

The funding requirement by activities and application areas is given in Table 3.2. A summary of the funding by activities for the period covered by this plan is given below.

Activity	Funding Requirement FY 1972-1977 Millions of Dollars
• Research	3.725
• Development	22.165
• Field Test	12.650
• Evaluation	10.470
• Promulgation	1.365
	50.375

5.1.3 Funding by Pollutant

The matrix of capability needs, Part 2, Section 2, has been used to assign the funding to specific pollutants. If a task involves more than one pollutant, the funding assignment reflects a pro-rata share of the task cost to each pollutant. The funding by pollutant and application area year is given in Table 3.3. The funding requirement by pollutant is summarized below.

Pollutant	Funding Requirement FY 1972-1977 Millions of Dollars
• Sulfur Oxides	3.54
• Oxides of Nitrogen	3.72
• Particulates	10.84
• Hazardous Pollutants	4.70
• Carbon Monoxide	1.50
• Hydrocarbons	6.07
• Odors	4.10
• Halogen	1.86
• Oxidants	1.23
• Other Pollutants	3.575

5.2 Funding for Replacement and/or Improvement of Measurement Methods

Once measurement techniques are developed and in use for one to two years, some techniques will be unacceptable in routine practice, others will need major or minor improvements. It is assumed that 50% of all techniques will be completely acceptable, 20% will require minor and 20% major improvements and 10% replacements. The cost of minor improvements is assumed to be 30% of development of a new instrument, of major improvements 60% of new instrumental development. The total factor of 0.28 is multiplied times the average yearly cost of measurement technique development, and this amount is added to the costs for the second fiscal year following, e.g., 28% of the base funding for FY 1972 is added to the FY 1974 funding requirements. Since there is no way to ascertain which specific tasks will require this additional effort, it is not possible to allocate the funds to specific items.

5.3 Funding for Future Requirements

The funding requirements defined so far only provide for measurement techniques to satisfy the measurement needs imposed by current legislation. The nation's air pollution control program is however still in the formative stages and new legislation can be expected during the period covered by this plan. It is anticipated that future legislation will require the availability of improved instrumentation, e.g., higher sensitivity and better specificity. Obtaining this degree of improvement in measurement capabilities will require substantial advances in the state of the art and accomplishing these advances will require long lead time. A research and development program to provide for advancement of the state of the art of measurement technology is required. This program would be done "in-house" and through EPA sponsorship of research grants to the academic community. It is difficult to set an amount of funding for this activity although a figure of approximately 10% of the measurement development program base funding level or some 5 million dollars over the time period of this plan seems reasonable. Manpower limitations will require that this funding be concentrated in the last three years of the plan period.

5.4 Funding Summary

The total funding required in fiscal years 1972 to 1977 to implement the measurement technique development plan is 69 million dollars. In fiscal years 1973 to 1975, the funding required is two or three times that currently budgeted for FY 1972. Table 3.4 summarizes the funding required by fiscal year.

5.5 Manpower Required

The implementation of the measurement technique development plan will require EPA manpower in addition to the funding requirements previously discussed. This manpower will be needed to conduct the in-house programs, to monitor and administer the contract program and for general program supervision.

At the peak funding period of FY-1973, some 18 million dollars is required for the measurement development program. It is expected that 15 million dollars will be in contract programs requiring 30 people for contract monitoring and administration. About 65 people will be required for the in-house program and 20 people for general program supervision during this period, for a total manpower requirement of 115 people.

By FY-1977, it is anticipated that approximately 50% of the measurement development program will be "in-house" with emphasis on programs to advance the state-of-the-art. The 2.5 million dollars to be spent in the in-house programs will require some 80 people directly involved in laboratory programs. Contract monitoring and administration should require an additional 6 people, on the assumption that one person can monitor about 500 thousand dollars of contract research. At the relatively small size of the contracts let in the measurement development program, this amounts to 5-6 contracts per contract monitor. General program supervision will require an additional 19 people, for a total manpower requirement of 105.

AIR POLLUTION MEASUREMENT TECHNIQUE DEVELOPMENT TASK SUMMARY

Function/ Task Number	Pollutant/ Description	Activities 1/	Date 2/ Start	Date 2/ End	Total Funding $1,000's	Task Description
Research & Investigation						
RI - 1	SO_2, NO_x, CO, oxidants and trace metals	D, FT, E	1-6	2-6	525	Develop Personal Air Pollution Cumulative Exposure Monitors for SO_2, NO_x, CO, Oxidants and Trace Metals /3
RI - 2	Ragweed Pollen	R, D	0-6	2-6	350	Develop Standard Samples of Aeroallergen Materials with the Initial Effort on Ragweed Pollen
RI - 3	Aeroallergens	R, D, FT	0-6	4-5	510	Develop a Rapid Means for Identifying and Quantifying Aeroallergens in the Ambient Atmosphere
RI - 4	Effects Package	R, D, FT, E, P	0-6	3-10	535	Develop an Effects Package to Enable Assessment of the Damage Caused by Air Pollution to Economically Important Materials
RI - 5	Multi-Pollutant	R	1-6	2-6	200	Conduct a Cost Benefit Analysis of Remote Sensing Techniques Applied to Routine Air Pollution Control
RI - 6	Plume Opacity	D, FT	0-6	3-6	625	Develop a Practical Field Instrument for the Remote Measurement of Plume Opacity
RI - 7	Part. Mass	D, FT, E, P	2-6	4-6	340	Develop the Data Interpretation Techniques to Enable Remote Measurement of Particulate Mass Loading
RI - 8	Gaseous Pollutants of Sources Point	R, D, FT, E, P	0-6	3-10	1525	Develop a Practical Field Instrument for the Remote Measurement of Gaseous Pollutants Emitted from Single Sources

Function/ Task Number	Pollutant/ Description	Activities 1/	Date 2/ Start	Date 2/ End	Total Funding $1,000's	Task Description
RI - 9	Integrated Emissions of Aggregated Source	R, D, FT, E, P	0-6	4-9	990	Develop a Practical Field Instrument Based on the Use of Long-Path Integrated Measurement Techniques for the Measurement of Emissions from Area Sources
RI - 10	Temperature Profiles	D, FT	0-6	1-6	400	Develop and Evaluate an Advanced Prototype Instrument to Remotely Measure Vertical Temperature Profiles
RI - 11	Wind Speed and Turbulence Profiles	D, FT	0-6	1-9	230	Develop and Evaluate a Prototype Instrument Based on the Laser Cross-Beam Technique to Measure Wind Speed and Turbulence Profiles
RI - 12	Wind Speed and Turbulence Profiles	D, FT	0-6	1-9	265	Develop the Data Handling Techniques Required to Obtain Wind Speed and Turbulence Profiles Using Ground-Based Accoustical Measurement Techniques
RI - 13	Moisture Profile Measurements	D, FT	1-6	3-6	550	Develop an Instrument Based on Optical Dispersion Techniques for Moisture Profile Measurements and Field Test the Measurement Method
Ambient Air						
IQA - 1	SO_2	D, FT, E P	0-7	2-10	280	Develop and Evaluate an Instrumental Method for Continuous Measurement of SO_2
IQA - 2	SO_2	D, FT, E P	0-7	2-10	335	Develop and Evaluate an Instrument for 24 Hour Cumulative Sampling and Analysis of SO_2
IQA - 3	S, $R_xS_xH_x$	D, FT, E P	0-7	2-10	285	Develop and Evaluate Instrumental Methods for Total Gaseous S Compounds and for Specific Sulfur-Containing Compounds

Function/ Task Number	Pollutant/ Description	Activities 1/	Date 2/ Start	Date 2/ End	Total Funding $1,000's	Task Description
IQA - 4	H_2S	D, FT, E P	0-7	1-11	210	Develop and Evaluate A Manual Method for 1 Hour or Less Cumulative Sampling and Measurement of H_2S
IQA - 5	H_2SO_4	R, D, FT, E, P	0-7	2-10	285	Develop a Manual Method for Molecular H_2SO_4 (Sulfuric Acid Mists)
IQA - 6	Part. Mass	D, FT, E P	0-7	2-7	180	Develop Beta-Gauging Techniques to Replace the Photometric Measurement of Particulates Collected on the Tape Sampler
IQA - 7	Part. Mass	R, D, FT, E, P	0-7	3-7	510	Develop and Evaluate An Improved Instrumental Method to Measure Hourly Particulate Mass Loading
IQA - 8	Part. Mass	D, FT, E, P	1-7	2-10	200	Develop an Improved Filter Medium for Use in Cumulative Measurement of Total Particulate Mass by Hi-Vol Equipment
IQA - 9	Part. Mass	FT, E, P	1-7	3-11	155	Field Test and Evaluate Techniques for an Improved Instrumental Measurement of Cumulative Particulate Mass Loading
IQA - 10	Part. Size	D, FT	1-7	2-9	125	Test and Evaluate Commercial Instruments for Size Distribution of Suspended Particles
IQA - 11	Respirable Part.	R, D, FT, E, P	1-7	4-10	635	Develop New Instrumental Techniques for Respirable Particles, Including the Smaller Particles of 0.1 to 2 Micron Size
IQA - 12	Visibility	D, FT, E, P	0-7	2-10	170	Field Test and Evaluate Available Instruments to Measure Visibility

Function/ Task Number	Pollutant/ Description	1/ Activities	Date 2/		Total Funding $1,000's	Task Description
			Start	End		
IQA - 13	Part.	D, FT	1-7	2-10	225	Develop and Evaluate Laboratory Methods for Determining the Composition of Collected Particulate Matter.
IQA - 14	CO	E, P	3-6	3-10	85	Test and Evaluate Currently Available Instruments Based on G.C. - FID for Instrumental Measurement of CO at Normal Ambient Levels
IQA - 15	CO	D, FT, E, P	1-6	2-10	165	Field Test Alternate Methods of Ambient Level CO Measurement and Conduct Evaluations as soon as Developments Appear to Justify an Alternate Official Method
IQA - 16	CO	D, FT, E, P	0-6	2-10	260	Develop Simple Instrumental Methods for Cumulative Sampling and Analysis of CO
IQA - 17	NO_x	E, P	0-6	0-10	110	Evaluate the Jacob Hochheiser Modified Saltzman Method for NO_2
IQA - 18	NO_2	R, D, FT, E, P	1-6	3-10	385	Conduct Research and Development Leading to an Improved Analytical Method for Ambient NO_2
IQA - 19	NO_2	D, FT, E, P	0-6	2-10	385	Complete the Development of Instruments for the Continuous Measurement of NO_2
IQA - 20	NO_2	D, FT, E, P	0-6	3-3	260	Develop Simple Instrumental Methods for Cumulative Sampling and Measurement of NO_2
IQA - 21	NO	D, FT, E, P	0-6	2-3	210	Complete Development and Evaluation of Instrumental Methods for Continuous Measurement of NO

Function/ Task Number	Pollutant/ Description	1/ Activities	Date 2/ Start	Date 2/ End	Total Funding $1,000's	Task Description
IQA - 22	NO	D, FT, E, P	0-6	3-3	260	Develop and Evaluate Instruments for Cumulative Sampling and Analysis of NO
IQA - 23	HNO_3	D, FT, E, P	0-6	2-10	210	Develop Analytical Methods for Ambient Molecular HNO_3
IQA - 24	Total Oxidants	FT, E, P	0-6	1-10	160	Evaluate the KI Instrumental Method for Total Oxidants and Correlate the Measured TOX Values with Values Obtained by the Other Oxidant and Ozone Measurement Methods Now in Use
IQA - 25	Ozone	E, P	1-6	1-9	110	Evaluate an Ozone Instrument as an Alternate Official Method for Total Oxidants
IQA - 26	Ozone	D, FT, E, P	1-6	3-10	285	Develop and Evaluate a Simple Instrumental Device for Cumulative Sampling and Analysis of Total Oxidants or Ozone
IQA - 27	HC	E, P	1-1	1-7	85	Evaluate the G.C. - FID Instrumental Method for Determination of Total Hydrocarbons Above Methane
IQA - 28	Specific HC's	D, FT, E, P	1-6	3-10	335	Develop Modifications of the G.C. - FID Instrumental Method for Specific Hydrocarbons
IQA - 29	Reactive HC's	R, D, FT, E, P	0-6	4-10	460	Develop and Evaluate Instruments for Measurement of Reactive Hydrocarbons as a Class
IQA - 30	Aldehydes	R, D, FT, E, P	0-6	4-8	435	Develop and Evaluate Instrumental Methods to Routinely Measure Aldehydes

Function/ Task Number	Pollutant/ Description	Activities 1/	Date 2/		Total Funding $1,000's	Task Description
			Start	End		
IQA - 31	BaP	D, FT	0-6	1-8	125	Evaluate Available Measurement Procedures for an Interim Manual Method for Analysis of Benz-a-Pyrene
IQA - 32	BaP	D, FT, E, P	1-6	4-3	260	Develop and Evaluate Automated Instrumental Methods for the Determination of Benz-a-Pyrene
IQA - 33	POM's	R, D	1-6	3-12	450	Continue Development of Methods for Analysis of Additional Specific Carcinogenic Compounds
IQA - 34	HF, F	D, FT, E, P	1-6	2-10	165	Test and Evaluate Instrumental Methods for Gaseous HF
IQA - 35	F .	D, FT, E, P	1-6	3-10	210	Develop and Evaluate Manual Methods for Both Water Soluble and Insoluble Fluoride Particulates for the Determination of Total Fluorides
IQA - 36	HCl, Cl_2	D, FT, E, P	1-6	3-10	285	Develop and Test a Chlorine/HCl Instrumental Detector Technique for Issurance as an Official [Instrumental] Method
IQA - 37	Asbestos	E, P	0-6	1-3	135	Evaluate Measurement Methods Based on Visual Counting for an Interim Manual Method for Asbestos
IQA - 38	Asbestos	R, D, FT, E, P	1-6	5-3	635	Continue Research for Techniques which can lead to an Instrumental Method for Asbestos
IQA - 39	Hg	D, FT, E, P	0-6	2-10	210	Develop and Evaluate Available Instrumental Technique for Measurement of Mercury

Function/ Task Number	Pollutant/ Description	1/ Activities	Date 2/ Start	Date 2/ End	Total Funding $1,000's	Task Description
IQA - 40	Be	D, FT, E, P	1-6	3-10	335	Field Test and Evaluate Currently Available Manual Methods for Volatile Be as an Interim Method
IQA - 41	Be	D, FT, E, P	0-6	3-5	285	Develop and Field Test an Instrument for the Continuous Measurement of Ambient Levels of Volatile Be
IQA - 42	Pb	R, D, FT, E, P	1-6	4-6	285	Evaluate Available Manual Techniques for Organic and Volatile Pb
IQA - 43	Cd	D, FT, E, P	2-6	4-8	335	Field Test and Evaluate Currently Available Manual Analytical Techniques for Volatile Cd
IQA - 44	Cd	D, FT, E, P	1-6	4-6	385	Develop and Field Test an Instrument for the Continuous Measurement of Ambient Levels of Volatile Cadmium
IQA - 45	As, Se, P	D, FT, E, P	1-6	4-6	690	Develop a Method for Measurement of Volatile Compounds of Toxic Non-Metals, i.e., Arsenic, Selenium and Phosphorous
IQA - 46	Trace Metals	D, FT, E, P	1-6	4-6	615	Develop Manual Methods for Volatile Compounds of the Trace Metals
IQA - 47	Odors	FT, E, P	0-6	3-6	315	Conduct Field Tests and Evaluations Leading to an Official Method for Odor Panels
IQA - 48	N	D, FT, E, P	1-6	4-3	335	Develop and Evaluate Instruments for Measurement of Reduced Nitrogen Compounds
IQA-49	Odors	R	1-6	3-12	300	Continue Correlation Studies Among Odor Response, Odor Persistence, and Measured Levels of Specific Odorants in Complex Mixtures

Function/ Task Number	Pollutant/ Description	1/ Activities	Date 2/ Start	Date 2/ End	Total Funding $1,000's	Task Description
Stationary Sources						
IQS - 1	Total Sulfur Oxides	FT, E, P	3-6	3-11	400	Field Test and Evaluate Manual Analytical Methods for Determining Total Sulfur Oxides (Particulate Sulfate, Sulfuric Acid Mist SO_2 and SO_3) at Source Level Concentrations
IQS - 2	SO_2	FT, E, P	0-6	1-3	525	Complete the Field Test and Evaluate Automated Continuous Monitors for SO_2 at Emission Sources
IQS - 3	Sulfuric Mist	R, D, FT, E, P	0-6	3-4	305	Develop and Evaluate an Automated Monitor for Sulfuric Mist from Sulfuric Acid Plants
IQS - 4	NO_x	E, P	0-6	1-3	85	Evaluate PDS Manual Analytical Method for Source Level Concentrations of Nitrogen Oxides
IQS - 5	Part. Nitrate, HNO_3 Mist	D, FT, E, P	0-6	2-10	235	Develop and Evaluate Manual Methods for Determining Particulate Nitrate and Nitric Acid Mist from Stationary Sources
IQS - 6	NO_x	FT, E, P	0-6	1-3	270	Complete the Field Test and Evaluate Automated Analyzers and Monitors for NO_x
IQS - 7	Part.	D, FT	1-6	2-10	150	Develop an Automated Isokinetic Sampling Devise for Use in the Measurement of Particulates
IQS - 8	Part. Mass	FT, E, P	0-6	1-8	1290	Test and Evaluate the Federal Manual Method for Total Particulate Mass Loading Measurements

Function/ Task Number	Pollutant/ Description	1/ Activities	Date 2/ Start	End	Total Funding $1,000's	Task Description
IQS - 9	Part. Mass	D, FT, E, P	2-6	5-3	510	Develop a Constant Volume Sampling Procedure which will Permit the Measurement of Total Particulate Mass Loading with appropriate Dilution to Represent the Probable Particulate Formation of the Effluent Gases after Leaving the Stack
IQS - 10	Part. Mass	D, FT, E, P	0-6	2-10	1715	Develop an Instrument for and Evaluate Continuous Measurement of Total Particulate Mass Loading
IQS - 11	Visible Emissions	FT, E, P	0-6	1-10	235	Promulgate a Manual Method for Visible Emissions Based on White Smoke Guides
IQS - 12	Visibility of Effluent Plumes	R, FT, E, P	0-6	2-3	740	Develop and Evaluate a Transmissometer for In-Stack Automated Measurement of Visibility of Effluent Plumes and Relate Opacity Measurement to Human Observations
IQS - 13	Part. Size	D, FT	0-6	1-10	150	Develop a Manual Method for Determining Particle Size Distribution in the Range of 0.05 to 0.5μ
IQS - 14	Particle Size Distribution	D, FT	0-6	2-10	375	Develop and Evaluate an Automated Sampler/ Analyzer to Determine Particle Size Distribution
IQS - 15	No. of Particles	D, FT	1-6	2-10	130	Evaluate Instruments to Sample and Analyze for the Number of Particles in a Gas Sample
IQS - 16	Particle Composition	D, FT	0-6	4-3	450	Develop and Test an On-Stream Analyzer for Measurement of Composition of Particulates
IQS - 17	Asbestos	FT, E, P	0-6	1-10	155	Evaluate Manual Methods of Analysis for Asbestos

Function/ Task Number	Pollutant/ Description	Activities 1/	Date 2/ Start	Date 2/ End	Total Funding $1,000's	Task Description
IQS - 18	Hg	FT, E, P	0-6	2-3	180	Evaluate Manual Methods of Analysis for Mercury
IQS - 19	Be	D, FT, E, P	1-6	2-9	155	Develop and Evaluate Manual Methods of Analysis for Beryllium
IQS - 20	Hg	Ft, E, P	1-6	2-10	155	Evaluate Automated Instruments for Measuring Mercury Emissions
IQS - 21	Asbestos	D, FT, E, P	1-6	4-3	310	Develop and Evaluate Automated Asbestos Emission Monitors
IQS - 22	Be	R, D, FT, E, P	1-6	4-10	355	Research, Develop and Test Automated Instruments for Continuous Monitoring of Beryllium Emissions
IQS - 23	CO	D, FT, E, P	0-6	2-3	310	Evaluate Available CO Instruments for Manual and Automated Measurements
IQS - 24	HC	D, FT, E, P	0-6	1-10	365	Evaluate Available Instruments for Measuring Total Hydrocarbons
IQS - 25	Organic Compounds	D, FT	1-6	2-10	350	Evaluate Gas Chromatographic Systems Including Separation Columns and Detectors for Measuring Specific Organic Compounds in Effluent Cases
IQS - 26	H_2S and Totally Reduced S Odors	D, FT, E, P	0-6	2-3	360	Evaluate Commercially Available Instruments for Determining H_2S and Totally Reduced Sulfur Odors from Stationary Source Emissions
IQS - 27	NH_3RNH_2	D, FT, E, P	0-6	3-3	260	Develop Tests and Evaluate Appropriate Columns for the Analysis of Ammonia and Amines from Effluent Gases to Determine the Specific Concentration of the Odorants

Function/ Task Number	Pollutant/ Description	Activities 1/	Date 2/		Total Funding $1,000's	Task Description
			Start	End		
IQS - 28	RCOOH, RCHO	D, FT, E, P	1-6	4-3	365	Develop Tests and Evaluate Commercially Available Separation Columns for Determining Organic Acids and Aldehydes
IQS - 29	Odors	R	0-6	2-6	275	Determine the Chemical Constituents which are Responsible for Odors from Pulp and Paper Mills, Petroleum Refineries, Petrochemical Plants, Sewage Sludge Incinerators and Animal Rendering Plants
IQS - 30	F	D, FT, E, P	0-6	2-8	245	Test and Evaluate Manual Analytical Methods for determining Fluorides
IQS - 31	Cl	D, FT, E, P	0-6	2-3	140	Test and Evaluate the Manual Analytical Methods for Determining Chlorides
IQS - 32	F	D, FT, E, P	0-6	2-11	250	Test and Evaluate the Available Commercial Instruments for Automated Measurement of Fluorides
IQS - 33	HCl, Cl	D, FT, E, P	1-6	3-3	140	Test and Evaluate the Available Commercial Instruments for Automated Measurements of Hydrogen Chloride and Total Chlorides
IQS - 34	Cd	D, FT, E, P	1-6	2-10	180	Develop and Evaluate Manual Methods for Analysis of Cadmium
IQS - 35	Pb	D, FT, E, P	3-6	3-3	155	Develop Manual Methods for the Measurement at Source Emission Levels of Gaseous Compounds of Lead
IQS - 36	As, Se, P	D, FT	1-6	3-3	300	Develop Manual Methods for Source Emission Level Measurements of Gaseous Compounds of Arsenic, Selenium and Phosphorous
IQS - 37	Trace Metals	D, FT	2-6	4-3	550	Develop Manual Methods for the Source Emission Level Measurements of Gaseous Compounds of the Trace Metals

Function/ Task Number	Pollutant/ Description	Activities 1/	Date 2/		Total Funding $1,000's	Task Description
			Start	End		
IQS - 38	Temperature Profile	D, FT, E, P	1-6	3-3	205	Develop Techniques for Determining the Temperature Profile Across Stack
IQS - 39	Flow Velocity Profile	D, FT, E, P	0-6	3-10	255	Develop Techniques for Determining the Flow Velocity Profile Across Stack
Mobile Sources						
IQM - 1	Exhaust Sampling System	D, FT	1-6	2-10	150	Develop and Evaluate a Simplified Exhaust Flow and/or Carburetor Air Intake Sensor to Control the Proportional Sampling Rates for Use with the Raw Exhaust Sampling System
IQM - 2	On-the-Road Sampling System	D, FT	2-6	4-10	350	Simplify and Evaluate the Constant Mass Sampling System for Potential Use On-the-Road to Confirm the Validity of the Operating Test Cycles for Measurements to Determine Compliance with the Light Duty Vehicle Emission Standards
IQM - 3	Particulate Mass Sampling	D, FT, E, P	0-6	2-10	460	Develop and Evaluate a Sampling Procedure for Particulate Total Mass Loading Consistent with the Currently Accepted Constant Mass Sampling Procedure
IQM - 4	Sampling Procedures Gasoline Engines	D, FT, E, P	0-6	1-11	210	Develop and Evaluate Sampling Procedures to Obtain Representative Emissions from Heavy Duty Gasoline Powered Engines
IQM - 5	Sampling Procedures Diesel Engines	D, FT, E, P	1-6	2-10	210	Develop and Evaluate Sampling Procedures to Obtain Representative Emissions from Heavy Duty Diesel Powered Engines
IQM - 6	Sampling Procedures Gas Turbine	D, FT, E, P	0-6	3-10	260	Develop and Evaluate Sampling Procedures to Obtain Representative Emissions from the Auto Gas Turbine

Function/ Task Number	Pollutant/ Description	Activities 1/	Date 2/ Start	End	Total Funding $1,000's	Task Description
IQM - 7	Sampling Procedures, Other Advanced Power Plants	D, FT, E, P	1-6	4-6	1000	Develop and Evaluate Sampling Procedures for External Combustion and Other Advanced Automotive Power Plants
IQM - 8	Asbestos	D, FT, E, P	0-6	2-10	310	Develop and Evaluate a Sampling and Measurement Procedure for Asbestos Particles Emitted During Operation of the Motor Vehicle
IQM - 9	Rubber Particles	D, FT, E, P	1-6	3-10	210	Develop and Evaluate a Sampling Procedure for Rubber Particles Emitted During Operation of the Motor Vehicle
IQM - 10	Assembly Line Sampling	D, FT, E, P	0-6	2-10	510	Develop and Evaluate a Simplified Procedure for Sampling at the End of the Line Compatible with the End of the Line Operating Test Cycle
IQM - 11	Inspection System Sampling	D, FT, E, P	1-6	3-10	470	Develop and Evaluate Sampling Procedures to Support State Inspection of Motor Vehicles in General Use Where the Measurement is Made According to the Selected Operating Procedure at a Fixed Location with Inertia Wheels or Other Appropriate Devices to Simulate Road Loading Conditions
IQM - 12	Spotcheck Idle Sampling	D, FT, E, P	1-6	3-10	340	Develop and Evaluate a Sampling Procedure for Use by the States in Inspecting Vehicles in General Use Where the Measurement is made as Spot Checks at Idle Conditions
IQM - 13	Sampling for Engine Tuning	D, FT, E, P	1-6	3-10	390	Develop and Evaluate Sampling Procedures for Use by Service Stations and Repair Facilities to Restore Motor Vehicles to Proper Emission Standards

Function/ Task Number	Pollutant/ Description	Activities 1/	Date 2/		Total Funding $1,000's	Task Description
			Start	End		
IQM - 14	Non-methane HC	D, FT, E, P	0-6	2-10	285	Develop and Evaluate a Continuous Analyzer for Measurement of Total Hydrocarbon Less Methane From Automotive Exhaust
IQM - 15	Heavy HC	D, FT	0-6	1-11	200	Develop an Analytical Technique to Enable Research Measurements to be Made of Heavy Hydrocarbon Emissions
IQM - 16	Heavy HC	D, FT, E, P	0-6	2-11	260	Develop and Evaluate an Instrument for Measurement of Heavy Hydrocarbons from Mobile Source Exhaust to Enable Routine Measurement of Heavy Hydrocarbons During Certification and Inspection Procedures
IQM - 17	CO	D, FT, E, P	0-6	2-10	260	Complete Development and Evaluate an Instrument for Carbon Monoxide with Improved Sensitivity
IQM - 18	NO_x	FT, E, P	0-6	0-9	135	Complete the Test and Evaluation of Routine Monitors for Total Nitrogen Oxide Emissions
IQM - 19	Polycyclic Organic Matter	D, FT, E, P	1-6	3-10	360	Develop and Instrumental Capability for Routine Monitoring of Polycyclic Organic Matter from Automobile Exhaust
IQM - 20	Reactive HC	D, FT	0-6	2-6	425	Develop Laboratory Analytical Methods for Determining Reactive Hydrocarbons Present in Automotive Emissions
IQM - 21	Reactive HC	D, FT, E, P	1-6	3-10	590	Develop the Instrumental Capability for Routine Measurement of the Reactive Components of Auto Exhaust

Function/ Task Number	Pollutant/ Description	1/ Activities	Date 2/		Total Funding $1,000's	Task Description
			Start	End		
IQM - 22	Oxygenates	D, FT	0-6	1-6	150	Develop Laboratory Analytical Methods for Determining Oxygenates from Auto Exhaust
IQM - 23	Oxygenates	D, FT, E, P	0-6	3-10	335	Develop an Instrumental Routine Method for Measuring Oxygenates Which Could be Used to Make Certification and Inspection Tests
IQM - 24	Odors	R	0-6	2-6	300	Chemically Characterize the Constituents Responsible for Odors from Diesels and Gas Turbines to Define Chemical Constituents Which Can be Selected as the Basis for a Quantitative Measure of Odor
IQM - 25	Odors	D, FT	0-6	2-3	275	Develop Analytical Techniques for the Measurement of Odors from Moving Sources
IQM - 26	Odors	D, FT	1-6	3-11	525	Develop Routine Instrumental Techniques for the Measurement of Odors from Moving Sources
IQM - 27	Part. Mass	FT	0-6	1-11	175	Evaluate the Available Methods for the Research Determination of Both Particulate Mass Loading and the Quantity of Fine Particulates from Mobile Source Vehicular Exhaust
IQM - 28	Part. Mass	R	1-6	3-6	300	Characterize the Particulate Emissions from Motor Vehicle Exhaust to Provide Information for Design of Routine Instrumental Monitors
IQM - 29	Part. Mass	D, FT, E, P	0-6	2-11	335	Develop a Routine Instrumental Capability to Measure Total Particulate Mass Loading and the Quantity of Fine Particulate

Function/ Task Number	Pollutant/ Description	Activities 1/	Date 2/ Start	Date 2/ End	Total Funding $1,000's	Task Description
IQM - 30	Smoke	FT, E, P	0-6	1-11	135	Complete the Evaluation of Smoke Meters for Both Diesel and Gas Turbine Exhausts to Determine Their Acceptability for Routine Monitoring of Smoke from Motor Vehicle Exhaust
IQM - 31	Jet Engine Gas Sampling	D, FT	0-6	1-11	275	Develop and Evaluate Sampling Procedures for Jet Engine Exhaust Gaseous Pollutants
IQM - 32	Jet Engine Part. Sampling	D, FT	1-6	2-10	275	Develop and Evaluate Sampling Procedures to Obtain Representative Emissions for Jet Engine Particulate Pollutants
IQM - 33	Fuel Additive and Emissions	D, FT, E, P	0-6	3-6	1000	Evaluate Measurement Techniques Developed for Air Pollutants and Trace Metals to Determine if they are Acceptable for Measurements to Support the Fuels and Fuel Additives Registration Program; Promulgate Official Measurement Techniques for Fuel Analysis of Additives
IQM - 34	Fuel Additive Emissions	D, FT	0-6	2-6	1695	**Develop the Procedures Required to Determine the Nature of and the Amount of Emissions Resulting From the Use of Fuels and Fuel Additives to Support the Fuels and Fuel Additive Registration Program**
Measurement Maintenance						
MP - 1	Equivalence	D, FT, P	0-6	2-9	290	Develop and Evaluate Procedures for Determining the Equivalency of New Measurement Techniques
MP - 2	Quality Control	R, D, FT, E, P	0-6	1-9	1600	Develop and Evaluate Standard Materials to Enable the Routine Calibration of Measurement Methods in General Use

Function/ Task Number	Pollutant/ Description	1/ Activities	Date 2/		Total Funding $1,000's	Task Description
			Start	End		
MP - 3	Quality Control	D, FT, E, P	0-6	2-10	390	Develop and Evaluate the Procedures and Test Samples for a Program to Periodically Evaluate the Performance Level of Users of Measurement Techniques

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1/ Activity Abbreviations:
R = Research
D = Development
FT = Field Test
E = Evaluation
P = Promulgation of official method unless otherwise noted

2/ Start and End dates are in terms of fiscal year and month where "0" is FY72, "1" is FY73, etc.: 1-7 would be the 7th month in FY73 or January, 1973.

3/ Abbreviations of pollutant descriptions are chemical symbols for sulfur dioxide (SO_2), carbon monoxide (CO), etc. NO_x= Nitrogen Oxides

PART 1

INTRODUCTION, BACKGROUND AND SCOPE

1. INTRODUCTION
2. BACKGROUND
3. SCOPE

1. INTRODUCTION

The purpose of this report is to present in detail a research, development, test and evaluation (RDT&E) plan for the Environmental Protection Agency, covering the fiscal years 1972 through 1977, to assure the availability of measurement techniques required in meeting the legal commitments imposed by the Clean Air Amendments of 1970.

The RDT&E plan will provide for development of air pollution measurement techniques: to support EPA research and investigations into the causes, effects and extent of air pollution; to identify and quantify air pollutants; to assist in the setting of standards and to determine compliance with standards; and to support a continuing EPA effort to maintain adequate measurement capabilities.

2. BACKGROUND

Instrumentation and analytical methods development is authorized under Sections 103 and 104 of the Clean Air Amendments of 1970. Other provisions of the Act require that instrumentation and analytical techniques be available for enforcing the standards that have been or will be set. The control of air pollution depends on the ability to determine the concentrations of pollutants in the ambient air and at the sources of the pollutants. The measurement of the pollutants depends on the availability of accurate and consistent instrumentation and/or methodology for measurement. No truly satisfactory methods or instruments are currently available for routine monitoring of ambient air or pollution sources for most pollutants, yet Federal, State, and local control agencies must soon enforce a series of controls on emissions from sources and must monitor the ambient air for the achievement of the National Ambient Air Quality Standards. The apparent potential market for instruments or measurement apparatus does not provide sufficient incentive for private industry to invest the required capital into an appropriate research and development program. Therefore, the Federal government must provide funding for the RDT&E phases of instrumentation and methodology development, with private industry undertaking the commercialization of instrumentation so developed.

Because of the acceleration of the air pollution control program called for in the Clean Air Amendments of 1970, particularly with respect to new source performance standards and emission standards for hazardous pollutants, a major expansion in the instrumentation and analytical methods development program is necessary. Of particular importance is the lack of methodology for measuring emissions from stationary sources. The special provisions of the Act for control agency authorities to measure and to require and specify the monitoring of emissions by stationary sources stress the importance of the availability of such methodology.

The pollutants or classes of pollutants that have been delineated to be of highest priority for control must be covered by adequate measurement techniques. At the minimum, manual methods must be developed for all of these pollutants, both for ambient air and source emissions. It is expected that approximately one-third of the pollutants will have continuous instrumentation developed for ambient air monitoring; approximately one-half of the pollutants will have stationary source monitoring instrumentation developed. In addition, many diverse categories of industries each with its own unique requirements must be covered for emissions sampling methodology. Instrumentation for measuring compliance with the standards applicable to 1975 and 1976 light duty motor vehicles (including advanced power sources) must be developed, as well as instrumentation to measure emissions from other mobile source classes such as heavy duty vehicles, aircraft, off-highway vehicles, locomotives, and vessels.

3. SCOPE

3.1 General

The RDT&E plan includes only the development of measurement techniques which contribute to the identification and quantification of air pollutants. The identification and quantification of the air pollutant can be used to discharge a legal commitment for measurement in a specific pollution control application area, e.g. source emission measurement, or it can be a supporting element in the general research or program maintenance areas. What determines whether a technique is included in the plan is whether it contributes to defining the pollutant and determining its level.

3.2 Discussion of the Scope of the Plan

Several important areas involving the application of measurement techniques are outside the scope of this RDT&E plan. These areas must be considered by EPA if the data obtained from the measurement techniques are to be useful in support of a program to control air pollution. Perhaps the most important is the specification of how to simulate representative emissions from moving sources and defining where to sample a source of emissions. We will consider the simulation of emissions in defining the measurement capabilities required for the moving source emission measurement area by referring to the need for an operating test cycle which is needed to simulate, at a fixed location, the on-the-road emissions from a motor vehicle. The problems of where to sample is encountered in determining where in an industrial source one makes the measurement(s) needed to determine the true emissions from the source. The development of techniques and procedures to determine how to simulate representative emissions from moving sources and the development of procedures to determine where to sample is not included in this RDT&E plan.

The plan provides for special measurement techniques in support of studies into the causes and extent of air pollution. Techniques provided for this area include remote pollutant monitoring capabilities to permit following the level of a pollutant from the point of emission into the ambient atmosphere and the development of meteorological measurement capabilities to provide information on the wind speed and turbulence and on the temperature profile in the planetary boundary layer.

The plan also provides for special measurement techniques in support of studies and investigations into the effects of air pollution. In the health effects area, this includes the development of personnel dosimeters to measure the exposure of individuals to air pollutants. The plan does not include the measurement techniques which will be required to determine the effect of that pollutant exposure level on the health of the individual.

The plan recognizes the need for but does not include the special measurement techniques which may be required to support a program to develop air pollution control technology. The basic tools needed for the identification and quantification of air pollutants in these programs are provided by measurement techniques to be developed for the source emission measurement application area. What is not included is special one-of-a-kind measurement needs, e.g. the distribution of limestone dust injected into a utility boiler as part of a SO_2 control project.

The plan provides no special techniques for measurements which may be required during air pollution episodes. The measurement techniques provided in the plan for ambient air quality monitoring and for source emission measurement are assumed to be versatile enough to meet measurement needs during periods of air pollution episodes.

The plan does not include specific tasks for development of measurement techniques for fine particulates. Fine particulates is a subdivision of the particulate class which is currently being considered for either a separate standard or for inclusion in a modified particulate standard. The fine particulate designation refers to the quantity of particulate with particle size below a certain size. Measurement techniques for fine particulates will involve a combination of techniques developed for the particulate total mass-loading and particulate size distribution groupings which are covered in the plan. The reader will note that tasks for these two groupings are frequently written to include additional work required in anticipation of a possible fine particulate standard.

The plan provides for the development of test procedures to support the program for determining the equivalency of new measurement techniques. It also provides for the development of test procedures, test samples and calibration gases required to support the quality control program. The plan does not provide the funding and manpower required to conduct either the equivalency determination or the quality control programs.

This plan does not include specific test procedures to control or monitor pesticides or radiation. There may be a need to add these areas of concern in future revisions.

3.3 Measurement Techniques Included in the Plan

The RDT&E plan provides for the development of two general types of measurement techniques: a manual method and an automated (instrumental) method.

The manual method is a technique suitable for intermittent measurements and requires the interaction of an operator with the measurement procedure. In its most basic form, the individual making the measurement obtains a sample of the atmosphere or stream containing the pollutant and returns the sample to a laboratory where the level of the pollutant is determined using a suitable analytical procedure. The sampling procedure can be short or it can involve collection of the sample over a period of days or even weeks. Included in the manual method category is the development of portable measurement instruments for the most prevalent pollutants. These instruments will enable governmental representatives to conduct spot inspections of source emissions to determine compliance with the emission standards.

The automated instrumental method, permits unattended repetitive measurements of the pollutant level. Once the instrument has been installed and calibrated, the instrument automatically samples and analyses the pollutant at a selected repetition rate. The repetition rate depends on the intended use of the instrument and can vary from continuous measurement to measurements made at specified intervals of every few minutes or hours. The automated instrumental method is intended to be suitable for continuous monitoring of pollutants.

PART 2

MEASUREMENT CAPABILITIES REQUIRED

1. LEGAL JUSTIFICATION FOR THE MEASUREMENTS REQUIRED
    - 1.1 Procedure Used to Determine Measurement Capabilities Required
    - 1.2 General Requirements
    - 1.3 Measurement Capabilities Required to Support Research and Investigations
    - 1.4 Measurement Capabilities Required to Identify and Quantitate Air Pollutants
        - 1.4.1 Ambient Air Quality Measurements
            - 1.4.1.1 National Ambient Air Quality Standards
            - 1.4.1.2 National Emission Standards for Hazardous Air Pollutants
            - 1.4.1.3 Measurement Requirements
            - 1.4.1.4 Summary of Measurement Capabilities Required
        - 1.4.2 Stationary Source Emission Measurements
            - 1.4.2.1 Standards of Performance for New Stationary Sources
            - 1.4.2.2 National Emission Standards for Hazardous Air Pollutants
            - 1.4.2.3 Implemental Plans
            - 1.4.2.4 Measurement Requirements
            - 1.4.2.5 Summary of Measurement Capabilities Required
        - 1.4.3 Moving Source Emission Measurements
            - 1.4.3.1 Special Considerations
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            - 1.4.3.4 Measurement Techniques to Support the Regulation of Fuels
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PART 2
(CONTINUED)

1.5 Future Plans of the Environmental Protection Agency
  1.5.1 Source Categories for New Source Performance Standards
  1.5.2 Pollutants Under Consideration for Future Control
  1.5.3 Additional Moving Source Emission Controls
1.6 Measurement Techniques to Support the Programs Required to Maintain Adequate Measurement Capabilities
  1.6.1 Equivalency Determination
  1.6.2 Quality Control Program

2. MATRIX - SUMMARY OF THE MEASUREMENT CAPABILITIES REQUIRED

PART 2

MEASUREMENT CAPABILITIES REQUIRED

This portion of the report is divided into two sections: one deals with the legal justification for the measurements required, and the other gives a complete summary of the current status of and needs for measurement capabilities in a matrix chart. The first section analyzes the measurement capability required to assure the timely availability of analytical methods and instrumentation needed to meet the legal commitments imposed by the Federal, State and local governments and on private citizens by the Clean Air Amendments of 1970. Section two described a matrix chart which is included to give an easy to use reference and summary of measurement capabilities required. The matrix lists pollution sources, and specific pollutants to be measured and shows at various intersections the current status of measurements, methods and additional requirements needed to achieve the desired measurement capabilities.

1. LEGAL JUSTIFICATION FOR THE MEASUREMENTS REQUIRED

1.1 Procedure Used to Determine the Measurement Capabilities Required

This section of the report describes the procedure used to determine what these measurement needs are and when the measurement capability will be needed. At this time, there is no comprehensive official list of measurement needs nor a timetable for their application that can be consulted. It is necessary to anticipate many of these needs so that research and development efforts can be undertaken to assure the timely availability of measurement techniques required by the promulgation of air quality and emission standards and by the implementation of control programs and special research studies.

In determining these measurement needs, we have analyzed the legislation, "The Clean Air Amendments of 1970," to determine both the broad areas of application and the specific goals of this Nation's program to achieve clean air. These goals will require the availability of measurement techniques if they are to be successfully accomplished.

These goals were further refined by considering the administrative promulgations which have been issued by the Environmental Protection Agency. While these promulgations cover only a relatively few of the anticipated measurement needs, they provide an official indication of the trend and direction of the air pollution measurement program. These promulgations indicate what is to be measured, where the measurements will be made, how the measurements will be made and who will be responsible for making the measurements. All of these factors are important in specifying the capability of measurement techniques.

Information on additional pollutants to be measured and on additional sources at which measurements will be required were obtained by considering the future plans of the Environmental Protection Agency. These plans also provide timetables for measurement needs.

1.2 General Requirements

The Clean Air Amendments of 1970 provide broad guidelines for the control of air pollution and establish the framework within which measurement techniques must operate as effective tools in support of the air pollution control program. An analysis of this legislation suggests three broad areas for inclusion in the measurement techniques development plan:

(1) Measurement techniques to support research and investigations relating the causes, effects and extent of air pollution.

(2) Measurement techniques to identify and quantitate data on air quality and source emissions to assist in the setting of standards and to determine if pollution levels comply with the standards.

(3) Measure techniques to support a continuing program to maintain adequate measurement capabilities required by the Nation's air pollution control program.

The research and development required in each of these broad areas is the subject of one section of this report. In the sub-sections to follow, an analysis of the legislation and of recent adminsitrative actions to execute the legislation will enable a more detailed definition of the goals in each of these areas.

1.3 Measurement Capabilities Required to Support Research and Investigations

Section 103 of the Amendments of 1970 continues a national program to conduct research and investigations relating to the causes, effects, extent, prevention and control of air pollution. This program will require the availability of special, often one of a kind, measurement techniques.

While many of the specific measurement capabilities required to support this program during the next five years cannot be foreseen at this time, the current direction of the research and investigation program suggests that measurement capabilities will be required to support programs involving the health and welfare effects of air pollution, the dispersion of air pollutants, the interaction of pollutants within the planetary boundary layer and the development of emission control technology. As these programs progress, additional measurement capabilities will be required.

A further analysis of the measurement techniques needed to support studies on the health and welfare effects of air pollution suggests the development of personal exposure level dosimeters and economic effect measurement packages. Studies on the dispersion of air pollutants will require the capability to remotely sense the pollutants as will studies on the interaction of pollutants within the planetary boundary layer. The latter studies also require the capability to remotely measure meteorological profiles within the boundary layer.

1.4 Measurement Capabilities Required to Identify and Quantitate Air Pollutants

The identification and quantification of data on air quality and source emissions to assist in the setting of standards and to determine if pollution levels comply with the standards requires a measurement capability in the following application areas:

(1) Ambient air quality measurement.

(2) Stationary source emission measurement.

(3) Mobile source emission measurement.

1.4.1 Ambient Air Quality Measurement

Section 109 of the Clean Air Amendments of 1970 requires the promulgation of national ambient air quality standards (NAAQS). The NAAQS are ambient air quality standards, the attainment of which is requisite to protect either the public health or welfare. Section 112 of the Amendments of 1970 designates hazardous air pollutants, the emission of which is controlled by national emission standards for hazardous air pollutants (NESHAP). Pollutants covered by NAAQS and NESHAP are expected to be measured in the ambient air.

1.4.1.1 National Ambient Air Quality Standards

The pollutants to be covered under national ambient air quality standards (NAAQS) are not specified in the legislation but result from the issuance of air quality criteria under Section 108. At this time air criteria have been issued for six pollutants leading to NAAQS for sulfur dioxide, particulates, nitrogen dioxide, oxidants, carbon monoxide and non-methane hydrocarbons.

1.4.1.2 National Emission Standards for Hazardous Air Pollutants

In addition to the pollutants covered under NAAQS, it is assumed that a capability will be needed to measure the ambient air quality level of those pollutants covered by national emission standards for hazardous air pollutants (NESHAP). A hazardous air pollutant is an air pollutant to which no ambient air quality standard is applicable and which may cause, or contribute to, an increase in mortality or an increase in serious irreversible or incapacitating illness.

Although no ambient air quality standards are applicable for materials described as hazardous air pollutants, the serious nature of these pollutants justifies their measurement in the ambient air. At this time, three pollutants have been designated as hazardous air pollutants: asbestos, mercury and beryllium.

1.4.1.3 Measurement Requirements

The Environmental Protection Agency has clarified the needs in the ambient air quality measurement area through its promulgation of Guidelines for State Implementation Plans in the August 16, 1971, issue of the Federal Register. In this promulgation, EPA specified a requirement for two distinct types of ambient air quality measurement techniques.

(1) a 24-hour sample of the pollution level conducted at 6-14 day intervals and

(2) a continuous measurement.

The 24-hour sample technique is amenable to field collection of the sample followed by a laboratory analysis using an acceptable analytical method to determine the level of pollution. However, the availability of an instrumental technique to cumulatively sample and analyze the pollutants on an intermittent basis would be desirable. The continuous measurement requirement will necessitate an automated instrumental technique.

Responsibility for operation of appropriate devices and methods to monitor data on ambient air quality is assigned to the States in Section 110 which specifies that EPA implementation plans provide for the implementation, maintaining and enforcement of the ambient air quality standards. The measurements required to obtain data for use in standard setting will be conducted by the Federal government employees. Federal, state and local government officials will be responsible for making ambient level measurements to determine both the compliance with air quality standards and to determine trends in air quality.

1.4.1.4 Summary of Measurement Capabilities Required

The above analysis of the legislative requirements and of EPA promulgations issued to date suggest the following needs in the ambient air quality level measurement area:

(a) A capability to measure the ambient air quality level of:
  (1) pollutants covered by NAAQS.
  (2) pollutants covered by NESHAP.

The pollutants for which measurements are now required are sulfur dioxide, particulates, nitrogen dioxide, carbon monoxide, non-methane hydrocarbons, asbestos, mercury, and beryllium.

(B) The availability of:
  (1) an analytical method for ambient air quality levels.
  (2) an automated intermittent sampler/analyzer for the most prevalent pollutants in the ambient air.
  (3) a continuous monitor for ambient air quality levels measurement.

1.4.2 Stationary Source Emission Measurement

The emissions from stationary sources of air pollution will be controlled under:

(1) Standards of Performance for New Stationary Sources.

(2) National Emission Standards for Hazardous Air Pollutants.

(3) Implementation Plans to Achieve National Air Quality Standards.

1.4.2.1 Standard of Performance for New Stationary Sources

Section 111 of the Amendments of 1970 requires the promulgation of standards of performance for new stationary sources (NSPS). The "standard of performance" limits the emissions that can be discharged from new or modified stationary sources for those categories of sources which contribute significantly to the endangerment of public health or welfare. The sources and the pollutants to be controlled under NSPS will be determined by the Environmental Protection Agency. If the pollutant is not covered by NAAQS or by NESHAP, the Amendment of 1970 requires that the states establish similar standards for existing plants.

At this time, NSPS have been issued for five industry sources and standards have been established for the emissions of particulates, sulfur dioxide, sulfuric acid mist and nitrogen oxides from some of these sources. In addition, the visible emissions from these sources or also controlled.

1.4.2.2 National Emission Standards for Hazardous Air Pollutants

Section 112 of the Clean Air Amendments establishes emission standards for hazardous air pollutants. At this time three pollutants have been designated as hazardous agents: beryllium, asbestos and mercury.

1.4.2.3 Implementation Plans

Section 110 requires that state implementation plans include limitations on emissions necessary to insure attainment and maintenance of NAAQS. At this time the pollutants covered by these plans are the six pollutants for which criteria documents have been issued. The potential sources to which these emissions standards can be applied is large and far exceeds those covered by NSPS.

1.4.2.4 Measurement Requirements

Section 114 authorizes the Environmental Protection Agency to require the owner or operator of any emission source to install and use monitoring equipment or methods and to sample emissions in such a manner as EPA shall prescribe for the purpose of developing implementation plans or any standard of performance under NSPS or NESHAP. This section also authorizes EPA representatives to sample any emission which the owner or operator of the source may be required to sample. The state implementation plans required under Section 111 also provide similar requirements for installation of equipment by owners or operators of existing sources to monitor emissions from these sources.

These legislative authorizations suggest as a minimum measurement capability an analytical method suitable for determining the emission pollutant level in the presence of interfering species in the effluent from the various sources. This necessitates that any analytical method selected for determining the emission level be evaluated for applicability in each industrial source being considered for emission standards. The requirement on owner/operators to monitor their emissions and on government representatives to periodically sample these emissions would be greatly facilitated if an automated measurement device were available. EPA proposed NSSPS for five industry sources in the Federal Register of August 17, 1971, and proposed continuous monitoring for sulfur dioxide, nitrogen oxides and visible emissions from some of these sources.

The measurements required will be conducted at all levels. Federal and State government employees will be concerned with measurement of emissions to obtain data for setting standards. Federal, State and local government employees will make measurements to determine if emissions are within the standards. Private citizens will be required to monitor the emission from sources under their control.

1.4.2.5 Summary of Measurement Capabilities Required

The above analysis of the legislative requirements of the Amendments of 1970 and of the EPA promulgations issued to date suggest the following needs in the stationary source emisions measurement area:

(A) A capability to measure the emission from stationary sources emitting:

(1) pollutants covered by NAAQS.

(2) pollutants covered by NESHAP.

(3) pollutants covered by NSPS.

The pollutants for which measurements are now required are: SO_2 (NAAQS) (NSPS), sulfuric acid mist (NSPS), nitrogen oxides (NAAQS) (NSPS), particulates (NAAQS), carbon monoxide (NAAQS), non-methane hydrocarbons (NAAQS), mercury (NESHAP), asbestos (NESHAP), beryllium (NESHAP).

(B) The availability of:

(1) a manual method consisting of sample collection followed by laboratory analysis using an analytical method suitable for source emission levels.

(2) an automated instrument for the continuous monitoring of source emissions.

(3) an automated portable measurement device to supplement collection of the sample followed by laboratory analysis.

1.4.3 Moving Source Emission Measurements

Section 202 of the Clean Air Amendment of 1970 provides for the establishment of emission standards from motor vehicles and motor vehicle engines. Section 231 of the Amendments requires the commencement of a study of emissions from aircraft leading to emission standards. Section 111 authorizes the regulation of fuels. This section of the report will consider the measurement techniques needed to support the air pollution control program for motor vehicles and aircraft and the fuel regulation program.

1.4.3.1 Special Considerations

The determination of emissions from moving sources differs from most measurements of air contaminants in that the measurement is normally made not at the place where we are concerned with reducing the atmospheric burden, i.e., on the road or in the air, but because of economic and practical considerations is made at a fixed location under test cycle conditions. This approach requires consideration of three factors to determine if the emission standard is being achieved: (1) the operating cycle, (2) the sampling procedure and (3) the analysis of the emissions.

The first of these factors, i.e., the test cycle, involves determining an operating procedure which simulates the actual emissions which would contribute to the atmospheric burden if the vehicle were operated on the road in a manner representative of normal driving patterns. While defining such operating procedures, which would enable the test to be conducted in an economic and practical manner without resorting to on the road or in the air testing of the vehicles, is an important element in defining the emissions from moving sources, consideration of the operating cycle is not within the scope of this measurement technique development plan. The other two factors, obtaining a representative emission sample from the operating test cycle and measuring the emission with appropriate analytical techniques or instruments, are considered in this plan.

The plan accordingly provides for two capabilities which are necessary to achieve the goals of the moving source emission control program: (1) a capability to representatively sample the emissions from moving sources and (2) the capability to analyze the emissions from the sources.

1.4.3.2 Measurement of Emissions from Motor Vehicles

Section 202 of the Clean Air Amendments requires that the Administrator of EPA shall by regulation prescribe standards applicable to the emission of any air pollutant from any class of new motor vehicles or new motor vehicle engines, which in his judgment is likely to cause or contribute to air pollution which endangers the public health or welfare. This section of the legislation establishes standards for three air pollutants: carbon monoxide, hydrocarbons, and oxides of nitrogen. Section 202 further specifies that the measurement techniques on which such standards are based shall be prescribed by regulation.

In EPA promulgations to execute this section of the legislation (Federal Register November 10, 1970), emission standards have been further broken down into those for gas fueled light duty and heavy duty engines and heavy duty diesel engines. As new propulsion systems are developed (gas turbines, advanced automotive power plants, etc.), additional emission standards are expected to be promulgated.

While Section 202 provides the general objective for motor vehicle emission measurements, the specific measurement needs are based on regulations described in subsequent sections of the Clean Air Amendments. These regulations cover two areas of application: measurement of emissions from new motor vehicles and measurement of emissions from vehicles in general use.

The regulations covering new motor vehicles and motor vehicle engines are found in Section 206. This section requires that the Administrator test, or require to be tested, in such manner as he deems appropriate, any new motor vehicle or new motor vehicle engine submitted by a manufacturer to determine whether such a vehicle or engine conforms with regulations prescribed under the standards. This testing is normally referred to as certification or compliance testing. The Administrator is also authorized to test new motor vehicles or new motor vehicle engines being manufactured to determine whether they in fact conform with regulations with respect to which a certificate of conformity was issued. For this purpose the test may be conducted by the Administrator directly or by the manufacturer in accordance with conditions specified by the Administrator. This group of tests is referred to as end-of-line or quality assurance testing. Section 206 emphasizes the responsibilities of the Administrator regarding the development of measurement techniques for the purpose of conducting these tests by requiring that the Administrator shall by regulation establish methods and procedures for making tests required for new motor vehicle emission control.

The justification for a measurement capability to determine compliance by vehicles and vehicle engines in actual use is found in Section 207. This section authorizes the Administrator to establish methods and procedures for determining whether motor vehicles and engines in actual use conform with the emission standards. This determination can be conducted through the surveillance testing of a sample of available vehicles or engines by the Administrator or through a comprehensive inspection program conducted by the states. The authority for state inspection programs is contained in Section 110 which requires that the state implementation plan provide to the extent necessary and practical for the periodic inspection and testing of motor vehicles to enforce compliance with applicable emission standards.

These programs require the measurement capability to conduct emission testing of vehicles in general use.

1.4.3.3 Measurement of Emissions from Aircraft

Section 231 of the Clean Air Amendments provides for the establishment of aircraft emission standards following a study of emissions of air pollutants from aircraft. The aircraft emission standards have not been issued at the time of this report. However, if and when such standards are promulgated, measurement techniques will be required to sample and analyze aircraft emissions.

1.4.3.4 Measurement Techniques to Support the Regulation of Fuels

Section 211 of the Clean Air Amendment provides for regulation of fuels and fuel additives. For the purpose of regulation of fuels and fuel additives, the Administrator may require the manufacturer of a fuel or fuel additive to furnish the description of available analytical techniques that can be used to test and measure any additive in such fuel and to determine the emissions resulting from the use of the fuel or additive contained in such fuels, or the effect of such fuel or additive on the emission control performance for any vehicle or vehicle engine. This requires that the Administrator develop methods and information on the procedures for sampling and analysis of fuels and fuel additives to determine if the analytical methods furnished by the fuel or fuel additive manufacturer comply with legal requirements.

1.4.3.5 Summary of Measurement Capabilities Required

The analysis of the legislation and of EPA promulgations suggests that the following needs in the moving source emission measurement area:

(A) Measurement technique development programs in three major areas:

  (1) Motor vehicle emissions (including gasoline fueled light and heavy duty engines and heavy duty diesel engines).

  (2) Aircraft emissions.

  (3) Fuels and fuel additives.

(B) A capability to measure the emissions from:

  (1) new motor vehicles which will be the responsibility of the Federal government (certification program) and the manufacturers.

  (2) vehicles in general use which will be the responsibility of the Federal government (surveillance program) and the states (inspection program).

The pollutants for which measurements will be required are: carbon monoxide, hydrocarbons and nitrogen oxides.

The techniques to meet these requirements must consider:

(1) the sampling problem.

(2) the identification and quantization of the pollutants.

1.5 Future Plans of the Environmental Protection Agency

Available plans of the Environmental Protection Agency have been considered to anticipate additional measurement techniques which may be required. Information which has been considered includes the projected schedules for source categories for new source performance standards, a listing of pollutants for which air pollution controls are being considered and the schedule for potential moving source emission controls. The following listings and future dates of standards promulgation represent estimates to enable the scheduling of measurement requirements and must not be construed as rigid; they are subject to change.

1.5.1 Source Categories for New Source Performance Standards

The source categories for new source performance standards have been divided into five groups. The Group 1 sources include steam generators greater than 25 MW, cement plants, municipal incinerators, sulfuric acid plants and nitric acid plants. The performance standards for the Group 1 sources were promulgated on December 23, 1971. The additional groups of sources, with estimated promulgation dates and the pollutants for which emission standards are anticipated follow:

ESTIMATED SCHEDULES FOR NEW SOURCE PERFORMANCE STANDARDS PROMULGATION (FOR MEASUREMENT REQUIREMENTS PLANNING PURPOSES)

Group 2

Designation Date:	12/1/71
Proposal Date:	4/1/72
Promulgation Date:	7/1/72

Industry	Pollutants
Asphalt Batch Plants	Particulates, Visible Emissions
Petroleum Refineries	Particulates, Visible Emissions, CO, H_2S, HC
Rendering Plants	Odors - Panel Method Referee
Steam Generators, 25 MW and Less	Visible Emissions
Brass and Bronze Refining	Particulates, Visible Emissions
Iron and Steel Mills	Particulates, Visible Emissions
Sewage Treatment Plants	Particulates, Visible Emissions
Secondary Lead Smelters	Particulates, Visible Emissions

Group 3

Designation Date:	8/1/72
Proposal Date:	12/1/72
Promulgation Date:	3/1/73

Copper Smelters	Particulates, Visible Emissions, SO_2, Acid Mist
Lead Smelters	Particulates, Visible Emissions, SO_2, Acid Mist
Zinc Smelters	Particulates, Visible Emissions, SO_2, Acid Mist

Group 3
(Cont'd)

Industry	Pollutants
Aluminum Reduction Plants	Particulates, Visible Emissions, Fluorides
Pulp and Paper Mills	Particulates, Visible Emissions, SO_2, TRS
Coke Plants	Visible Emissions
Phosphate Fertilizer Plants	Particulates, Visible Emissions, Fluorides
Phosphorus Reduction Plants	Particulates, Visible Emissions, Fluorides, Acid Mist (H_3PO_4)
Animal Feed Defluorination Plants	Particulates, Visible Emissions, Fluorides
Ferro-Alloy Plants	Particulates, Visible Emissions
Coal Cleaning Plants	Particulates, Visible Emissions

Group 4

Designation Date: 4/1/73
Proposal Date: 8/1/73
Promulgation Date: 11/1/73

Petrochemical Plants
Grey Iron Foundries
Sulfur Recovery Units
Gas Turbines
Lime Plants
Grain Milling and Handling
Hydrochloric Acid Plants
Phosphoric Acid Plants
Paint and Varnish
Graphic Arts Plants

Group 5

Designation Date: 12/1/73
Proposal Date: 4/1/74
Promulgation Date: 7/1/74

Industry
Soap and Detergent Manufacture
Cotton Gins
Auto Assembly Plants
Chlorine and Caustic Plants
Rendering Plants
Sewage Treatment Plants
Iron and Steel Plants
Petroleum Refineries

The pollutants for which emission standards are planned have not been determined at the time of this writing for the last two source category groups.

1.5.2 Pollutants Under Consideration for Future Control

Additional pollutants for which controls are being considered for implementation and the areas specified in the Amendments of 1970 under which the control programs are expected to be initiated are listed for planning purposes as follows:

PLANNING ASSUMPTIONS FOR POLLUTION CONTROL

Pollutant	Potential Control Area
Non-Methane Hydrocarbons	Aircraft Emission Standards
Odorous Materials	NSPS
Fluorides	NSPS
Lead	NSPS
Lead	Fuel Regulation
Fine Particulates	NAAQS
Cadmium	NESHAP
Arsenic	NESHAP
Polychlorinated Biphenyls	NESHAP
Nickel	NESHAP
Polycyclic Organic Matter	NAAQS
Vanadium	NESHAP
Manganese	NESHAP
Chromium	NESHAP
Reactive Organics	Under Consideration
Selenium	Under Consideration
Cl_2-HCl	Under Consideration
Copper	Under Consideration
Zinc	Under Consideration
Boron	Under Consideration
Barium	Under Consideration
Tin	Under Consideration
Phosphorus	Under Consideration
Lithium	Under Consideration
Synthetic Organics	Under Consideration

1.5.3 Additional Moving Source Emission Controls

For planning purposes, the following measurement capabilities have been developed to be consistent with potential controls:

Pollutant	Application Area	Technique Requirement
Odor	Aircraft and Diesel Emission Standards	Research Method Routine Meas.
Fine Particulates	Motor Vehicle Emission Standards	Routine Meas.
Aldehydes and Reactive Organics	Motor Vehicle Emission Standards	Research Method Routine Meas.
Rubber and Asbestos	Motor Vehicle Emission Standards	Routine Meas.

1.6 Measurement Techniques to Support the Programs Required to Maintain Adequate Measurement Capabilities

Section 1.4 indicated the measurement capabilities required to identify and quantitate data on air quality and source emissions to set standards and determine if pollution levels comply with the standards. In this section, the measurement technique needs to support the programs required to maintain these measurement capabilities are indicated. Two programs which will require measurement support are:

(1) Equivalency Determination
(2) Quality Control

1.6.1 Equivalency Determination

The measurement methods promulgated by EPA are expected to be supplemented by additional measurement techniques developed by private industry in response to competitive forces in the market place. These techniques must be tested to determine their equivalency with the techniques promulgated by EPA. Failure to provide a mechanism for such an equivalency determination will deny participation of potentially improved and lower cost measurement techniques, particularly instruments, in the Nation's air control program. The capability to conduct equivalency determinations must be established. This plan provides for the development of the methods, procedures and standards required for an equivalency determination program.

1.6.2 Quality Control Program

There is a need for a continuing quality control program to insure that the methods and instruments being used are giving the correct answers. Without such a program a valid comparison of data obtained by different operators or using different instruments is not possible. This could lead to frequent court challenges of measurements made by EPA or state inspectors which do not agree with similar measurements made by private citizens and could seriously hinder the air pollution control program. The quality control program must provide the capability for routine calibration of measurement methods which are in general use and must also provide for a periodic evaluation of user competence. This plan provides for the development of measurement methodology and materials required to support the quality control program. It does not include the supply of such materials for implementation of the program.

2. MATRIX - SUMMARY OF THE MEASUREMENT CAPABILITIES REQUIRED

The general needs defined above, the pollutants currently listed for control and the plans of the Environmental Protection Agency have been considered in defining the total measurement capabilities required. The summary of these capabilities is presented in the form of a matrix chart whose elements are the pollutants, and the needs. A total of 48 different pollutants are listed in twelve separate categories as noted below. (The number of specific pollutants in each category is shown in parenthesis.)

1. Oxides of Sulfur (3)
2. Oxides of Nitrogen (4)
3. Particulates (7)
4. Hazardous Air Pollutants (3)
5. Carbon Monoxide (1)
6. Organic Compounds (5)
7. Halogens (3)
8. Not Pollutant Specific (1)
9. Odors (6)
10. Oxidants (1)
11. Other Pollutants (13)
12. Aeroallergens (1)

The needs shown on the matrix total 60 and are separated into six categories as noted below.

1. Measurement Techniques to Support EPA Programs on Research and Investigations (5)
2. Ambient Air Quality Monitoring - Sensor Development (2)
3. Stationary Source Emission Measurements
    a. Sensor Development (2)
    b. Group 1 (5)
    c. Group 2 (8)
    d. Group 3 (11)
    e. Group 4 (10)
    f. Group 5 (4)

4. Other Industries Emitting Hazardous Pollutants (1)

5. Moving Source Emission Measurements
   a. Sensor Development (2)
   b. Application Areas: Motor Vehicles (5) and Aircraft (1)
   c. Fuel and Additive Registration and Regulation (1)
6. Measurement Techniques to Support EPA Programs to Maintain Measurement Capabilities (3)

A capability requirement is indicated on the matrix by an entry at the pollutant-need intersection which represents the development task statement number under which an RDT&E effort to achieve the measurement capability will be found in Part 3. There are a total of 138 task statements separated into the following categories. Each task is identified by number and code as shown in parenthesis.

1. Measurement Techniques to Support EPA Research and Investigations (RI 1-13)

2. Measurement Techniques to Identify and Quantitate Air Pollutants
   a. Ambient Air Quality Measurement (IQA 1-49 or 50)
   b. Stationary Source Emission Measurement (IQS 1-39)
   c. Moving Source Emission Measurement (IQM 1-34)
3. Techniques to Support EPA Programs to Maintain Adequate Measurement Capabilities (MP 1-3)

Some tasks may appear at more than one intersection. For example IQS 10 for the measurement of total particulate mass loading intersects with a number of industries, i.e., steam generators, incinerators, cement plants, etc. There also may be some intersections which require more than one task, as for example at the intersection of Nitric Oxide and Remote Sensing RI 8 and 9 are required to satisfy the needs. A number of intersections are blank because not all pollutants apply to all the industries or needs shown on the chart.

The matrix also provides a rapid means for the user of the report to determine how many different application areas must be considered in developing measurement techniques for identifying and quantifying a particular pollutant. The matrix also enables a quick determination of the different capability requirements which an individual development task provides for.

PART 3

RESEARCH AND DEVELOPMENT NEEDS

1. STRUCTURE OF THE TASK STATEMENTS
    - 1.1 Rationale
    - 1.2 Activities
        - Research
        - Development
        - Field Test
        - Evaluation
        - Promulgation
    - 1.3 Resources Required
    - 1.4 Schedules
2. MEASUREMENT TECHNIQUES TO SUPPORT EPA RESEARCH AND INVESTIGATIONS
    - 2.1 Effects and Extent of Air Pollution
        - 2.1.1 Health Effects
        - 2.1.2 Economic Effects
    - 2.2 Remote and Long Path Sensing
        - 2.2.1 Remote Sensing of Particulates
        - 2.2.2 Remote Sensing of Gases
    - 2.3 Meteorological Measurements
        - 2.3.1 Temperature Profile Measurement
        - 2.3.2 Atmospheric Turbulence and Wind Measurements
        - 2.3.3 Moisture Profile Measurements
3. MEASUREMENT TECHNIQUES TO IDENTIFY AND QUANTITATE AIR POLLUTANTS
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        - 3.1.1 Introduction
        - 3.1.2 Specific Requirements

3-1-b

PART 3
(CONTINUED)

- 3.1.2.1 SO_2 and Sulfur Compounds
- 3.1.2.2 Particles
- 3.1.2.3 Carbon Oxides
- 3.1.2.4 Nitrogen Oxides
- 3.1.2.5 Ozone and Oxidants
- 3.1.2.6 Organic Compounds
- 3.1.2.7 Halogen
- 3.1.2.8 Hazardous Air Pollutants
- 3.1.2.9 Other Pollutants
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3.2 Stationary Source Emission Measurements

- 3.2.1 Introduction
- 3.2.2 Specific Requirements
    - 3.2.2.1 Sulfur Oxides
    - 3.2.2.2 Nitrogen Oxides
    - 3.2.2.3 Measurement of Total Particulate Mass
    - 3.2.2.4 Visible Emissions (Opacity)
    - 3.2.2.5 Other Particulate Properties
    - 3.2.2.6 Hazardous Substances
    - 3.2.2.7 Carbon Monoxide
    - 3.2.2.8 Organic Compounds
    - 3.2.2.9 Odors
    - 3.2.2.10 Halogens
    - 3.2.2.11 Other Pollutants
    - 3.2.2.12 Other Tasks

3.1C

PART 3
(CONTINUED)

3.3 Moving Source Emission Measurements
  3.3.1 Introduction
  3.3.2 Motor Vehicle Emission Measurements
    3.3.2.1 Sampling Motor Vehicle Emissions
    3.3.2.2 Gaseous Pollutants
    3.3.2.3 Particulate Pollutants
  3.3.3 Aircraft Emissions
  3.3.4 Measurement Procedures to Support EPA Programs to Register and Regulate Fuels and Fuel Additives
4. TECHNIQUES TO SUPPORT EPA PROGRAMS TO MAINTAIN ADEQUATE MEASUREMENT CAPABILITIES
  4.1 Equivalency Testing
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5. RESOURCES REQUIRED
  5.1 Consolidation of Funding Requirements on Task Statements
    5.1.1 Funding by Application Area
    5.1.2 Funding by Activities
    5.1.3 Funding by Pollutant
  5.2 Funding for Replacement and/or Improvement of Measurement Methods
  5.3 Funding for Future Requirements
  5.4 Funding Summary
  5.5 Manpower Required

1. STRUCTURE OF THE TASK STATEMENTS

The following sections of the report will compare the state-of-the-art in the three application areas with the measurement needs identified in Part 2. This comparison will lead to a definition of RDT&E tasks that remain to be accomplished to achieve the desired measurement capabilities. This section explains the rationale behind some of the information contained in the tasks sheets which will be developed and also defines the terms used in the task descriptions.

1.1 Rationale

Once the need for a measurement technique has been defined, EPA initiates a sequence of action steps which is not unlike that involved in taking any new product from the concept stage to its availability for use by the eventual customer. This sequence of actions involves a number of activities which must be performed by EPA, either in-house or by its contractors, and also involves several review and decisions points. The eventual product of these actions is an official procedure for conducting the measurement, which the Administrator can promulgate by listing in the Federal Register. The RDT&E task includes the schedule and funding requirements for conducting these activities. The task also lists certain critical milestones: the date that the measurement technique is required to support EPA control plans and the dates that an interim and an official measurement technique can be expected.

For a given measurement technique not all activities in the action sequence are required; in many cases the state-of-the-art will enable EPA efforts to begin at the test and evaluation stage, using commercially available instruments. The relationship and scheduling among the various activities is shown in Figure 2.

1.2 Activities

The action steps leading to official EPA measurement techniques have been divided into five activities: research, development, field test, user evaluation and promulgation. While an attempt has been made to keep the definition of the activities consistent with OMB nomenclature, the divisions were selected to identify measurement technique development areas within EPA. This division was found to be useful in projecting resource requirements for individual activities based on prior EPA experience.

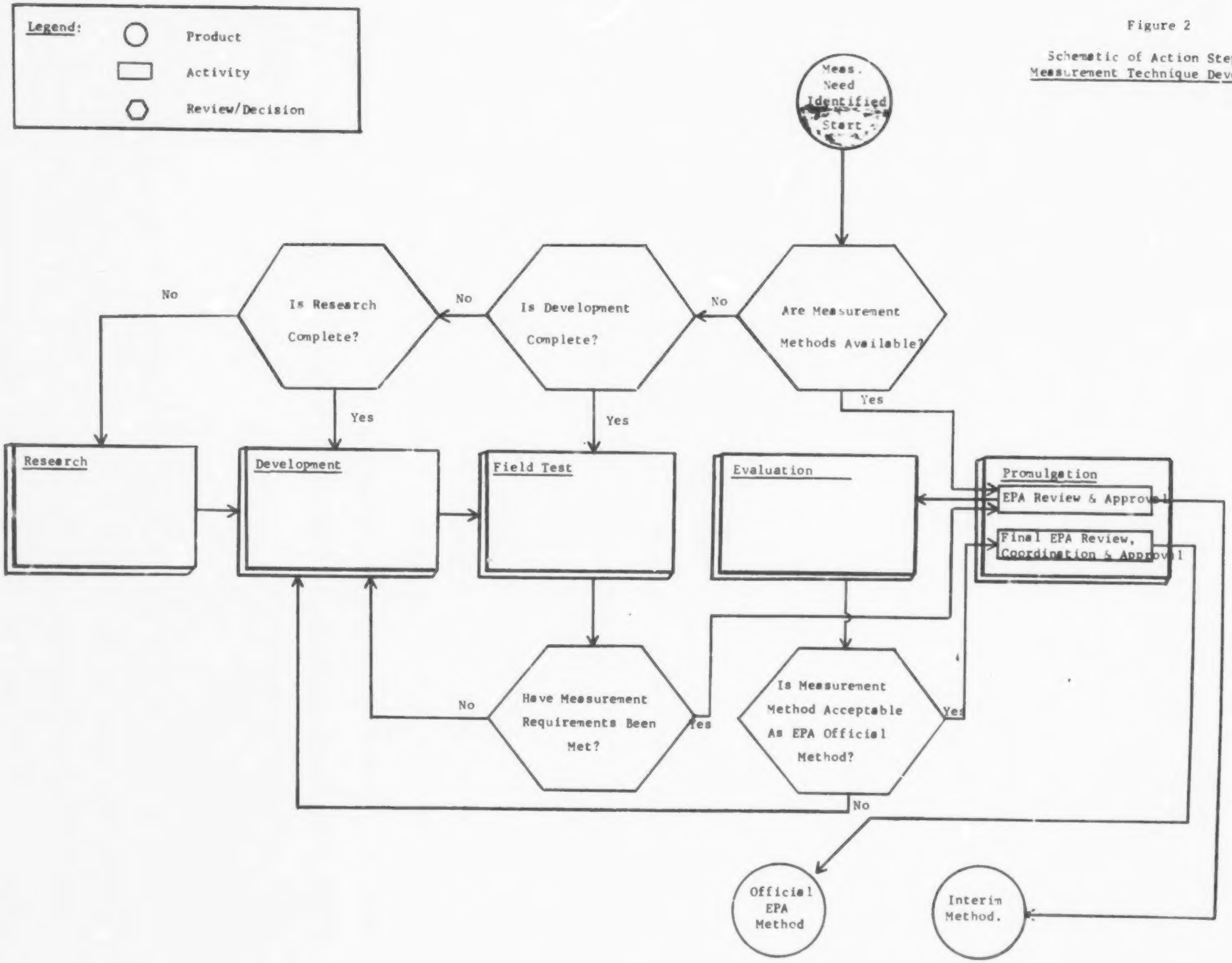
Research

The research activity involves the laboratory scale investigation of new measurement techniques. This includes basic research on new measurement concepts and analytical methods. The demonstration of the feasibility of the measurement technique concludes the research phase.

The research activity can be conducted in-house or by means of contracts and grants. This is the activity most likely to generate grant support for academic work.

Figure 2

Schematic of Action Steps in Measurement Technique Development


Legend:
Product
Activity
Review/Decision
Meas. Need Identified Start
Are Measurement Methods Available?
No
Yes
Is Development Complete?
No
Yes
Is Research Complete?
No
Yes
Research
Development
Field Test
Evaluation
Promulgation
EPA Review & Approval
Final EPA Review, Coordination & Approval
No
Have Measurement Requirements Been Met?
Yes
Is Measurement Method Acceptable As EPA Official Method?
Yes
No
Official EPA Method
Interim Method.

Development

The development activity provides a prototype analytical method or instrument. The end of the development activity is a laboratory test of the prototype to determine accuracy, operating characteristics, reproducibility, reliability, interfererences, responses and sensitivity. It is expected that such a laboratory test will be required even when commercially available measurement instruments are available. The development activity can be done in-house but normally is a contracted effort.

Field Test

The field test activity takes the new instrument or analytical method into the field under typical operating conditions to determine if it meets the measurement technique requirements. Based on the results of this field test the technique is either passed on to the promulgation activity as a potential interim method or is recycled to the development activity for additional work.

This activity will normally be performed under contract, although consideration must be given to conducting the test in conjunction with routine measurements made by state or local air pollution control agencies. Regardless of how the activity is performed, the close supervision and participation of the individuals responsible for development of the technique is required.

Evaluation

The evaluation activity marks the transition of the measurement technique from one that is known to be acceptable in the hands of experts to one that is acceptable for general use. This activity begins with the availability of a measurement technique, which, following a review by EPA, has been accepted as an interim measurement technique. The technique and the instructions for its use are then made available to a body of typical users who have not been directly involved in its development. If on review by EPA the results of the evaluation suggest that the measurement technique is acceptable for general use, and would be considered valid under legal investigation, its promulgation as an official EPA measurement method is initiated.

The procedure involved in the evaluation activity varies depending on the intended use of the measurement technique which is being evaluated. If the measurement technique is one that will be used primarily by a small group of relatively skilled scientists or engineers, e.g., a technique for conducting emission measurements required by the Federal motor vehicle emission certification program, the evaluation can be rapidly accomplished at low cost. On the other hand, if the measurement technique is to be used by a large number of individuals over whose qualifications EPA has no control then an extensive and costly collaborative test procedure may be required to insure that the measurement technique and the instructions for its use permit valid measurements in the hands of representative users. These procedures and the subsequent EPA review of the evaluation will assure that the official EPA measurement methods which will issue based on these results are sufficient to withstand any challenge pertaining to their applicability or validity, through the courts or otherwise.

The collaborative test program is expected to be widely used in the evaluation of measurement techniques for ambient air quality level monitoring, stationary source emission measurement, and motor vehicle emission inspections. The need for standard methods in the air pollution field made it imperative that a collaborative test program be undertaken. EPA is required by law to establish standards and to approve implementation plans developed by state air pollution control agencies. Such plans to be most meaningful require the availability of standard methods of analysis available for use by all concerned. Therefore, EPA initiated a program of this nature as a portion of a long-range effort in standardization which had been in progress for some time. Using various techniques to provide controlled atmospheres for testing, collaborative tests are being conducted in order to provide the necessary data to complete the process of standardization.

To provide a valid statistical evaluation, the participants in a collaborative test series should be representative of the ultimate users of the method. Since air pollution measurements are a matter of concern to many people, the users of the method in this case can be assumed to include laboratories of the federal government, state and local air pollution control agencies, private industrial plants of many different types, universities, and basic research organizations, among others. To date, approximately 150 laboratories have indicated a willingness to participate in the collaborative testing of ambient air quality level monitoring methods. A majority of these are state and local air pollution control agencies, although the other types of laboratories listed above are also represented. The various laboratories also vary in size from one- or two-man laboratories up to large organizations with a laboratory staff of several dozen people.

Promulgation

The promulgation activity is a frequently overlooked but very important part of the measurement technique development program. The activity involves an EPA in-house review of the measurement techniques and of the instructions for their use that are recommended for the air pollution control programs and also a review of the various field test and evaluation results. Based on these reviews the necessary instructions and techniques are formalized and comments on the proposed measurement techniques are solicited from advisory groups such as the Standardization Advisory Committee within EPA and the Intersociety Committee. The recommendations of the advisory groups form a basis for necessary revisions or modifications in the techniques and the instructions for their use, and final endorsement of the advisory groups is obtained.

The next step in the promulgation activity is EPA proposal of the measurement technique as an official measurement method, through publication in the Federal Register. This procedure allows time for outside comments. Comments received are considered, and a final version of the method is submitted for EPA promulgation as an official measurement method. The elapsed time required to conduct the promulgation activity is about four to five months, three months of which is the period allowed for comments following proposal of the method by EPA in the Federal Register.

The Intersociety Committee, whose counsel and endorsement of new measurement techniques is solicited, is a coordinating body presently supported by eight scientific and engineering societies. Present members include: Air Pollution Control Association, American Chemical Society, American Conference of Governmental Industrial Hygenists, American Industrial Hygiene Association, American Public Health Association, American Society for Testing and Materials, American Society of Mechanical Engineers, and Association of Official Analytical Chemists. This group has been supported financially by the Environmental Protection Agency and by its predecessor, the National Air Pollution Control Administration.

1.3 Resources Required

The task statement lists only the funding required to accomplish the task. The basis for these funding requirements is EPA experience on previous measurement development projects. It is recognized that, in addition to funds, other resources in the form of EPA manpower will also be needed to accomplish the task. These manpower requirements are not included on the individual task statements, but will be discussed in later sections of the report.

The funding allocated to an individual task is only sufficient to pursue one measurement technique to satisfy the measurement requirement. While this funding permits several concepts to be evaluated through the research activity, the funding level does not permit carrying out a parallel development or field test program on more than one concept. Additional funding will be required to cover the redevelopment and re-testing of those measurement techniques which do not live up to their expectations, if we are to insure that adequate measurement capabilities are achieved. Since the specific tasks which will require this additional funding cannot be specified at this time, we will add a general contingency for this purpose to the total program in a later section of the report.

1.4 Schedules

The task statements include the indication of one or more of three major milestones related to the measurement technique.

The first milestone is the assumed actual date by which the measurement technique is needed if EPA schedules for promulgation and enforcement of air quality level and emission standards are to be met. This date is based on planned EPA schedules for promulgation of standards when these are available, and has been estimated for those application areas and pollutants for which promulgation plans have not yet been established. The date shown on the task sheet as the date by which the measurement technique is needed is not the estimated date for promulgation of the standard which will require the availability of the measurement technique. Some form of measurement capability will be required before promulgation of the standard, to obtain data on air quality levels or emissions needed in determining the standards. Unless more specific information was available, it has been assumed that an interim manual method must be available at least nine months prior to the anticipated promulgation date. This provides for six months of measurement activity to obtain air quality or emission data prior to proposing the standards and the three month comment period between proposing the standard and its promulgation. It has been assumed further that an evaluated instrumental method will not be required for at least eighteen (18) months following promulgation of standards which require such a measurement technique. The 18 month period is based on the assumption that significant use of an instrumental technique will not occur until compliance with the air quality level or emission standards is required. In the source emission standards area, compliance must await the installation of adequate emission control techniques. Control equipment for existing stationary sources or for new stationary sources should take at least 18 months to design, procure and install. In the moving source area the time allocated for compliance with the standards has historically been in the order of two years. In the ambient air quality level monitoring area, one year has normally been given for the States to develop their implementation plans, and an additional four months provided for EPA review of the implementation plan prior to its acceptance.

The second milestone is the expected date on which an interim measurement technique would be available. On this date a field tested prototype measurement technique which has had a preliminary review and evaluation by the promulgation activity is available for use. The elapsed time required to reach this stage depends on the state-of-the-art and on the time needed to complete any activities required inclusive of the field test program.

The last milestone shown on the task statement is the date on which a fully evaluated measurement technique is expected to be available for proposal as an official EPA measurement method.

2. MEASUREMENT TECHNIQUES TO SUPPORT EPA RESEARCH AND INVESTIGATIONS

This section of the report describes the tasks required to develop the measurement techniques required to support EPA research and investigation programs on the effects and extent of air pollution.

2.1 Effects and Extent of Air Pollution

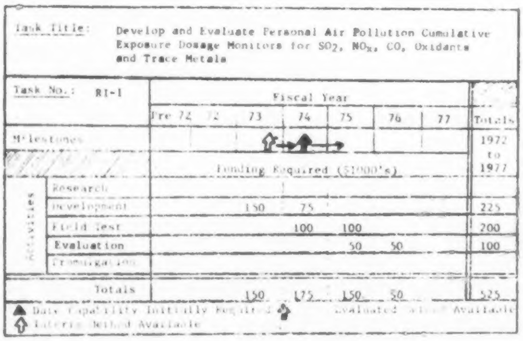
The Clean Air Amendments of 1970 call for special emphasis on research into the short- and long-term effects of air pollutants on public health and welfare. This includes an accelerated research program to improve the knowledge of the contribution of air pollutants to the occurrence of adverse effects on health, including the behavioral, physiological, toxicological and biochemical effects. This research can involve epidemiological studies, clinical and laboratory studies. In this section, the measurement technique development required to support these research programs will be discussed.

2.1.1 Health Effects

The health effect research program, like other EPA air pollution control programs, needs to identify and quantitate air pollutants. If the health effect need involves the identification and quantification of a pollutant which is now or is expected to be widely measured in the ambient air quality monitoring program, the necessary measurement technique development program is not covered in this section but is covered under the ambient air quality measurement technique development program. Pollutants which fall in this category are: pollutants covered by NAAQS or NESHAP, fine particulates in the respirable particulate size range, and trace metals. In addition, the health effects research studies will require the measurement of other pollutants and/or the measurement of the same pollutants in a manner different than that required in the ambient air quality monitoring program. The development of the necessary techniques to perform these measurements is covered herein.

The health effects research program has a need for personal air pollution monitors for various pollutants to obtain a better estimate of the exposure of individuals participating in the long term field studies. The movement of the individuals from one level of pollutant exposure to another during the course of these extended studies makes the average exposure estimates obtained from ambient air quality monitors unacceptable. The personal air pollution monitors should be reliable, cumulative exposure dosage monitors similar in size to radiation dosage badges. This type of personal monitor for air pollutant exposure is not available. The development of personal monitors for the same pollutants covered by NAQS and other selected pollutants should be immediately initiated.

TASK REQUIRED: Develop and evaluate personal air pollution cumulative exposure dosage monitors for SO_2, NO_x, CO, oxidants and trace metals. (RI-1)



Task Title: Develop and Evaluate Personal Air Pollution Cumulative Exposure Dosage Monitors for SO_2, NO_x, CO, Oxidants and Trace Metals

Task No.: RI-1		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	→ ▲ →	→			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			150	75				225
	Field Test				100	100			200
	Evaluation					50	50		100
	Promulgation								
Totals				150	175	150	50		525

▲ Date Capability Initially Required ⇧ Evaluated Method Available
⇧ Interim Method Available

Aeroallergens, while often a natural pollutant, are nonetheless a major air pollutant with at times serious effects on the health of individuals. The identification of specific aeroallergens is now a tedious procedure and new measurement techniques are required to permit routine quantification, if progress is to be made in determining their potential synergistic role in the health effects of other air pollutants. EPA is conducting an in-house program to develop these measurement techniques, although the lack of suitable standard aeroallergen samples is retarding progress in this area.

The development of suitable standard aeroallergen samples is required. Initially, the program should concentrate on development of standard ragweed pollen samples because of the widespread distribution and the adverse effect on many individuals of this aeroallergen.

TASK REQUIRED: Develop standard aeroallergen samples.
(RI-2)

The development of rapid means for measuring specific aeroallergens in the ambient atmosphere should be initiated. This task would begin at the research activity and should include determining the feasibility of specific chemical reactions which might be the basis

Task Title: Develop Standard Aeroallergen Samples.

Task No.: RI-2

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧					1972 to 1977
		Funding Required ($1000's)							
Activities	Research		75	75					150
	Development			100	100				200
	Field Test								
	Evaluation								
	Promulgation								
Totals			75	175	100				350

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

of identifying given aeroallergens as well as automated electro-optical techniques to classify aeroallergens based on their shape and size. Both of these approaches could be supported by research grants through their early development period.

TASK REQUIRED: Develop rapid means for measuring specific aeroallergens in the ambient atmosphere. (RI-3)

The above listing by no means completes the listing of measurement techniques required to support the health effects research studies. During preparation of the plan, additional measurement techniques were identified, but they did not involve the identification or quantification of an air pollutant. Accordingly, they are not within the scope of the plan. A listing of these additional needs follows to make organizations and individuals outside of the effects research program aware of the needs.

Instrumentation Needs for Health Effects Research

a. Development of a solid particle aerosol generator that can separate the larger particles so that only respirable particles get to the animals for use in animal inhalation studies.

b. Development of breath testers - e.g. for Hg, ambient pollutants and evidence of smoking.

Task Title: Develop Rapid Means for Measuring Specific Aeroallergens in the Ambient Atmosphere

Task No.: RI-3		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones						⇧	⬆		1972 to 1977
		Funding Required ($1000's)							
Activities	Research		75	75					150
	Development			100	100				200
	Field Test				50				50
	Evaluation					100			100
	Promulgation						10		10
Totals			75	175	150	100	10		510

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

c. Measurement of SOx and NOx in saliva.

d. Measurement of methemaglobin for NO.

e. Measurement of urine or salivary thiocyanates or acetonitriles to better define smoking biochemistry.

f. Measurement of pollutant metabolic products in biological systems.

g. Measurement of altered levels or types of metabolic products caused by pollutant effects, e.g. blood delta ALA dehydrase for Pb.

h. Extension to other pollutants of measurement techniques similar to the monitoring of pollens by looking at the sputum changes in people with bronchitis.

2.1.2 Economic Effects

The development of measurement techniques to support studies on the economic effects of air pollution, including the effects on plants and materials, is the subject of this section. A measurement of the long term effects of air pollution on materials is needed to define a pollution damage function. These measurements can be made using "effects packages". The effects package is a selection of materials in a suitable container which can be conveniently located throughout the country to determine the result of air pollution exposure on the materials. This enables EPA to assess what the economic penalty associated with dirty air really is. Effects package air pollution sampling stations are currently commercially available, but the components of the package do not permit measurement of the effect of air pollution on economically important materials, e.g., paints, galvanized products, tire-sidewall rubber, etc. A task to develop a more meaningful effects package should be initiated. This task would start with a research program to develop simple techniques for assessment of the economic damage function.

> TASK REQUIRED: Develop and evaluate an effects package to enable assessment of the damage caused by air pollution to economically important materials. (RI-4)

Economic penalties result from reduced visibility and odors. Reduced visibility often delays aircraft landings and can contribute to air and highway accidents. Odors can sharply reduce property values in the affected area. Measurement techniques to measure visibility and odors will be required for the assessment of economic effects. The development of these techniques is covered in the ambient air quality monitoring section.

The economics effects research program will also require specialized measurement techniques to assess the effects of air pollution on plants, e.g., measurement of vegetative damage. This type of measurement does not involve the identification or quantification of an air pollutant and accordingly is not covered in this plan. Rapid transfer of technology generated in NASA's earth resources measurement program to the air pollution effects surveillance effort may be possible.

Task Title: Develop and Evaluate an Effects Package to Enable Assessment of the Damage Caused by Air Pollution to Economically Important Materials

Task No.: RI-4

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧	⬆			
		Funding Required ($1000's)							1972 to 1977
Activities	Research		75	150					225
	Development			100	100				200
	Field Test				50	50			100
	Evaluation								
	Promulgation					10			10
Totals			75	250	150	60			535

▲ Date Capability Initially Required
⇧ Interim Method Available
⬆ Evaluated Method available

2.2 Remote and Long Path Sensing

This section of the report describes the measurement technique development tasks that are required to achieve a remote sensing capability in support of EPA research programs into the causes and extent of air pollution. These research programs include studies to obtain a quick and relatively coarse assessment of the distribution of pollution in a community atmosphere or from various source emissions; to assess the effectiveness of control techniques; to investigate chemical transformations, atmospheric transport and dispersion processes; to develop mathematical models of the pollution potential of urban atmospheres; and to develop design and performance criteria of instrument systems for routine field utilization.

Remote sensing instrumentation is currently unsuited for routine development for compliance monitoring. At present it is over-designed, complex, and prohibitively expensive. Nontheless, improvements in remote sensing techniques could lead to practical field instrumentation which would enable this measurement technique to play a major role in routine air pollution measurement programs. A cost benefit analysis to define the application areas in which remote sensing techniques would result in the most favorable cost effective measurement method should be undertaken.

TASK REQUIRED: Conduct a cost benefit analysis of remote sensing techniques applied to routine air pollution control. (RI-5)

Task Title:	Conduct a Cost Benefit Analysis of Remote Sensing Techniques Applied to Routine Air Pollution Control								
Task No.: RI-5		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones									1972 to 1977
		Funding Required ($1000's)							
Activities	Research			100	100				200
	Development								
	Field Test								
	Evaluation								
	Promulgation								
Totals				100	100				200

▲ Date Capability Initially Required ▲ Evaluated Method Available
△ Interim Method Available

Traditional methods of measurement consist of instrument systems that sample at a point in the ambient air or sample through a probe introduced within a source of emissions (in-stack sampling). Inadequacies of such systems to meet some current needs and recent advances in the technology of remote sensing have led to an EPA program of remote sensing applied to air pollution research studies and measurement activities.

2.2.1 Remote Sensing of Particulates

The earliest need was realized in EPA's (then APCO's) cooperative study with the Edison Electric Institute (EEI) in assessing the opacity of plumes from power plants. The conclusion of the study of the optical properties of these plumes was that optical transmission of the plume best characterized the aerosol loading in the emissions. Furthermore, an objective instrumental measurement of plume transmission was demonstrated to be feasible, in terms of remote sensing by "Lidar" techniques (Stanford Research Institute Contract). The EPA-EEI Cooperative Study was extended to include the development of a Lidar system (as a research tool) specifically for further assessment of the technique under field conditions and for the eventual development of a practical field device based on such a technique. The Lidar system was further advanced under development by contract with General Electric Company and the system was delivered in April 1971.

The G.E. system, as presently executed, doesn't lend itself to a practical field device in terms of portability, economy of cost, and laser hazards, with its high laser power requirements. A contract study with Stanford Research Institute is underway to investigate the possibility of utilizing the Lidar technique wherein the signal backscattered directly from the plume aerosol is analyzed and related to the transmission of the plume instead of the signal that is backscattered from the ambient air beyond the plume. The feasibility of such an approach will permit the use of a very low powered laser and the design of a practical field instrument. Another promising approach involves the use of a low powered continuous wave laser (compared to the present pulsed technique) in conjunction with frequency modulation techniques to give optical transmission.

The above program is concerned with the remote sensing of particulate air pollution. It will continue towards the initial objective of developing practical field instrumentation for the remote measurement of plume opacity.

TASK REQUIRED: Develop a practical field instrument for the remote measurement of plume opacity. (RI-6)

Once a remote plume opacity measurement technique has been successfully developed, EPA expects to extend the capability to remotely determine particulate mass loading. It is expected that this extention will not require new instrumentation development, but merely the development of techniques to interpret the data contained in the signal from the remote opacity measurement device to extract a meaningful determination of mass concentration.

TASK REQUIRED: Develop data interpretation techniques to enable remote measurement of particulate mass loading and field test the measurement method. (RI-7)

Task Title: Develop a Practical Field Instrument for the Remote Measurement of Plume Opacity

Task No.: RI-6		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧		⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			300	100				400
	Field Test		75		100	50			225
	Evaluation								
	Promulgation								
Totals			75	300	200	50			625

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop Data Interpretation Techniques to Enable Remote Measurement of Particulate Mass Loading and Field Test the Measurement Method

Task No.: RI-7		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones						⇧	⬆		1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development				150				150
	Field Test					75			75
	Evaluation					50	50		100
	Promulgation						15		15
Totals					150	125	65		340

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

2.2.2 Remote Sensing of Gases

Remote sensing of gases offers several advantages over point sampling. These include: more representative sampling by spectral integration and averaging over a long path in ambient air or across the diameter of a stack plume; avoidance of interfacing between analyzer and the stack with appropriate probes and sample conditioning such as dilution, gas cooling, particulate scrubbing, water condensation, etc.; the only effective way of executing a measurement of an extended source such as an oil refinery with undefined leakage sources, etc.

Electro-optical techniques in infrared emission and absorption spectroscopy appeared to offer the most advanced state of technology development in related areas such as gas measurement in planetary space studies and in chemical agent detection in the military. EPA's initial effort at remote sensing of SO_2 emissions in power plant emissions consisted of an IR feasibility study with Dalmo Victor followed by a prototype development of what might constitute a field instrument. Although the execution of the technique in terms of engineering the hardware was well done, the operation was unsatisfactory and an evalutation of the inadequacy was not determinable because of the lack of supporting research instrumentation for remote sensing.

A contractual program was initiated to provide remote sensing research instrumentation and data for the development of field instruments utilizing IR emission and absorption techniques for remote monitoring of sources and long path measurements in ambient air. A contract was undertaken with Convair of San Diego to develop a high resolution (0.1 cm^{-1}) scanning IR spectrophotometer (3 to 5.5 microns and 7 to 14 microns) with capability for both emission and absorption spectroscopy. This instrument is to provide field data on IR spectra of urban atmospheres and of emissions from various sources and is to be the ultimate reference in the field performance evaluation of prototype field instruments. An appropriate assessment of the performance of the Dalmo Victor prototype SO_2 monitor can be made with this Convair research instrument. The Convair instrument was delivered in the spring of 1971. A 3-month field program is currently underway in the Los Angeles area. The objectives of the field program are: to familiarize EPA's staff with the instrument's operation; to generate representative long path spectra (2 miles) of Los Angeles atmosphere under various smog conditions; to generate representative spectra of power plant source, incinerator source, and extended source, i.e., chemical complex or oil refinery.

Another IR research instrument system was developed under contract and delivered by Bendix in September 1970. This system is a multichannel spectrophotometer (7 to 14 microns), based on an earlier design for the Chemical Corps and modified to EPA's needs. This instrument has a range of capabilities that start somewhat below that of the Convair system and approach the simplest single channel prototype field device. A built-in computer (programmed to direct the procedure of operation of the instrument and to execute the operation) provides as many as 50 channels of analysis and can be degraded to a minimum of one channel. This is compared to Convair's 7000 channels of $0.1cm^{-1}$ spectral segments in the 7 to 14 micron spectral region. The Bendix system will permit the development of optimum design and performance specifications for a prototype field instrument that is minimized in channel requirements and adequate in accuracy, sensitivity, and specificity.

Paralleling the development of the field research instruments, a contract was undertaken with the Wave Propagation Laboratory of NOAA in

Boulder, Colorado to consolidate and generate as required high resolution IR spectral data on various pollutant gases, for the analyses of urban and source emission spectral data generated in the field. Contract effort included the development of an analytical scheme programmed for computer utilization whereby pollutant concentration data can be extracted from field spectra. Additional spectral parameter data are being obtained in a contract with Ford Aeronutronic of Newport Beach, California. This consists of high resolution, high temperature spectra of SO_2 for analyses of emission spectra from hot stack gases as compared to ambient air temperature of atmospheric spectra.

Remote sensing of nitric oxide (NO) in source emissions by IR emission is not feasible because the NO absorption line falls in the water absorption region in the 5 to 7 micron spectral region. A contract was undertaken with AVCO Everett to determine the feasibility of Raman scatter as a means of remote sensing of NO from power plant emissions. The Raman scattering cross-sections were determined for both SO_2 and NO in the laboratory and preliminary experimental data obtained in the field on a coal burning power plant. The instrumentation utilized was not optimum and suffered from large stray background noise, such that the sensitivity was inadequate to detect the SO_2 and NO concentrations in the plume.

Requests for proposals (RFP's) were issued by EPA to conduct field experiments with optimized available Raman scatter equipment. Review of the proposals led to the conclusion that at best the technique would still be a borderline case in sensitivity due to the low signal-to-noise ratio (S/N) inherent in Raman scatter technique. Simultaneously, other exploratory studies were indicating that an improvement in S/N in the order of 10^3 could be obtained in going to resonance Raman scatter and an improvement in S/N in the order of 10^4 to 10^5 could be obtained in fluorescent scatter techniques. It was concluded that more productive effort would be realized in pursuing these approaches at this time and cancelling any follow up on the RFP's on Raman scatter. This conclusion was further reinforced by an invitation from Langley Research Center, NASA to conduct a cooperative study wherein they wished to conduct Raman scatter measurements with their ongoing system on power plant sources and wanted EPA assistance in conducting supporting in-stack measurements to provide "ground truth" so-to-speak. EPA is planning to accept this invitation which serves the interest of both parties.

EPA has also initiated contracts to adapt advanced technologies in IR spectroscopy that have potential as second generation field instrument systems in remote sensing. These include the development of very low powered tunable IR diode lasers in a contract with the Lincoln Laboratories of MIT and long path IR laser coincidence spectroscopy in a contract with G. E. in Syracuse, N. Y.

EPA has funded research grants in long path and remote sensing instrument developments. These include:

A. Zaromb Research Foundation - Laser Stimulation of Raman Scattering as Source for Absorption Spectroscopy of Pollutant Emissions in Ambient Air.

B. University of Florida (Gainesville) - Correlation Spectroscopy.

Commercial prototype remote monitors of SO_2 and NO_2 (correlation spectroscopy) were utilized in a field studies contract that EPA had with Barringer Research, Inc. The objectives of these studies were to conduct a number of field experiments that may shed light on research questions relating results obtained by remote sensing to those by in-stack methods and those by long path to those by point sampling in ambient air. The experiments were also to give some information on the performance capability of this instrumentation under field conditions. This study included remote sensing from aircraft of NO_2 in a plume downwind and tracking of NO_2 in an air mass traversing a community. The results were informative but still of a preliminary nature. Present plans are to purchase a remote sensing system and further assess the performance in conjunction with the Convair system as a reference.

A continuing program to develop a practical field remote sensing capability to determine the emission of gaseous pollutants from single sources, e.g., stacks, must be maintained. This task will permit "in-site" sampling of the plume and detection at a distance of 1/4 to 1 mile from the source. The initial emphasis will be on the measurement of SO_2 and NO with later extention of the concept to NO_2, HCl and other pollutants.

TASK REQUIRED: Develop a practical field instrument for the remote measurement of gaseous pollutants emitted from single sources. (RI-8)

Task Title: Develop a Practical Field Instrument for the Remote Measurement of Gaseous Pollutants Emitted from Single Sources

Task No.: RI-8

		* Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧→		⬆→			1972 to 1977
		Funding Required ($1000's)							
Activities	Research		200	100					300
	Development		100	250	250	150			750
	Field Test			50	100	100			250
	Evaluation					100	100		200
	Promulgation					15	10		25
Totals			300	400	350	365	110		1525

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Instrumentation to provide the capability needed to measure the emissions from area sources, e.g., petrochemical facilities, should be developed. This instrumentation would be based on the use of long-path integrated measurement techniques. The required program could build on data obtained from the remote gaseous pollutant sensing programs and from DOD and NASA activities. The measurement capability provided by this technique will also enable measurement of integrated ambient air quality levels across valleys, along city streets, etc. This should greatly facilitate measurements required for research studies into the extent of pollution.

TASK REQUIRED: Develop a practical field instrument based on the use of long-path integrated measurement techniques for the measurement of emissions from area sources (TASK No. RI-9).

EPA has maintained an exchange of information of mutual interest in remote sensing with several government agencies having ongoing programs and made contact with others. These include NASA at Washington Headquarters, Langley Research Center, former Electronics Research Center, and Amos Research Center; Army Chemical Corps at Edgewood; Naval Research Laboratory, D. C.; Naval Weapons Laboratory, Dahlgren, Virginia; Air Force Cambridge Research Laboratories.

Task Title: Develop a Practical Field Instrument Based on the Use of Long-Path Integrated Measurement Techniques for the Measurement of Emissions from Area Sources

Task No.: RI-9

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧→		⬆		1972 to 1977
		Funding Required ($1000's)							
Activities	Research		100	75					175
	Development		100	250	150				500
	Field Test				100	50			150
	Evaluation					100	50		150
	Promulgation						15		15
Totals			200	325	250	150	65		990

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

2.3 Meteorological Measurements

The quality of the ambient air is the result of emissions of pollutants from discrete sources and the presence of geographical formations and climatological conditions which enhance or hinder the dispersive forces of the atmosphere. This section of the plan covers the research and development projects needed to establish the capability to measure the dispersive forces of the atmosphere and other atmospheric properties required for an understanding of the causes and extent of air pollution. The measurement capability provided by this section will also enable a timely advance prediction of local air pollution episodes.

Obtaining information on the dispersive forces acting in the lower two kilometers of the atmosphere above an urban area cannot be accomplished with conventional meteorological measurement techniques, because of air safety restrictions. Accordingly, EPA's support of meteorological measurement programs in recent years has focused on the development of remote techniques to measure these transport properties in the planetary boundary layer. These measurements provide information on the dispersive nature of the atmosphere and permit forecasting of the extent to which interactions between air pollutants and atmospheric processes will affect community air pollution levels. EPA's meteorology program is conducted by personnel on assignment from the National Oceanic and Atmospheric Administration of the Department of Commerce.

The meteorological measurement technique program includes three areas: (1) remote measurement of the atmospheric temperature profile; (2) remote measurement of wind speed and turbulence profiles and (3) measurement of atmospheric moisture profiles.

2.3.1 Temperature Profile Measurement

Because atmospheric temperature gradients (differences in temperature with increasing altitude) are among the factors that influence the transport and dispersion of air pollutants, and because of the limitations of conventional means of obtaining atmospheric temperature profiles, EPA has been supporting the development of remote sensing techniques. In this regard, a prototype radiometer for measuring vertical temperature profiles has been developed and successfully evaluated by EPA under contract with Sperry Rand. An advanced prototype radiometer for measuring temperature profiles suitable for field use is currently under development. This technique is based on sensing the radiation from atmospheric oxygen molecules in the millimeter radiation spectrum. Completion of the development and evaluation of an advanced prototype remote instrument to measure vertical temperature profiles is required.

TASK REQUIRED: Develop and evaluate an advanced prototype instrument to remotely measure vertical temperature profiles (RI-10)

Task Title: Develop and Evaluate an Advanced Prototype Instrument to Remotely Measure Vertical Temperature Profiles									
Task No.: RI-10		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧ →			⬆		1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		300						300
	Field Test			100					100
	Evaluation								
	Promulgation								
Totals			300	100					400

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

2.3.2 Atmospheric Turbulence and Wind Measurements

The wind speed and turbulence of the asmosphere at altitudes within the planetary boundary layer (up to 1500 m) are also factors that influence the transport and dispersion of air pollutants. Again the limitations of conventional methods of measuring wind speed and turbulence vertical profiles in urban areas necessitates a remote measurement capability. EPA is supporting development of a laser cross-beam technique which obtains information on wind speed and turbulence by focusing a laser beam on an area of the planetary boundary layer and looking at the back scatter of radiation. The construction and evaluation of a prototype of the laser cross beam technique for wind speed and turbulence profiles remains to be accomplished.

> TASK REQUIRED: Develop and evaluate a prototype instrument based on the laser cross-beam technique for measurement of wind speed and turbulence. (RI-11)

EPA is also sponsoring development of ground-based accoustical techniques as an alternate method to measure wind speed and turbulence profiles in the planetary boundary layers. An operational prototype is available but the technique to obtain the desired profiles from the data remain to be worked out. Once the necessary techniques are available a field test of the measurement method is required.

Task Title: Develop and Evaluate a Prototype Instrument Based on the Laser Cross-Beam Technique for Measurement of Speed and Turbulence

Task No.: RI-11

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		130	50					180
	Field Test			50					50
	Evaluation								
	Promulgation								
Totals			130	100					230

▲ Date Capability Initially Required
⇧ Interim Method Available
⬆ Evaluated Method Available

TASK REQUIRED: Develop the data handling techniques required to obtain wind speed and turbulence profiles from ground-based accoustical techniques and field test the measurement method. (RI-12)

2.3.3 Moisture Profile Measurements

NOAA is currently investigating optical dispersion techniques for application to moisture profile determinations. The timely development of an operational prototype for use by EPA and State Air Pollution Control Agencies will require EPA support of the development phase, followed by a field evaluation of the measurement method.

TASK REQUIRED: Support the development of the instrument based on optical dispersion techniques for moisture profile measurement and field test the measurement method . (RI-13)

Task Title: Develop the Data Handling Techniques Required to Obtain Wind Speed and Turbulence Profiles From Ground-Based Accoustical Techniques and Field Test The Measurement Method

Task No.: RI-12

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		135	80					215
	Field Test			50					50
	Evaluation								
	Promulgation								
Totals			135	130					265

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Development of an Instrument Based on Optical Dispersion Techniques for Moisture Profile Measurements and Field Test the Measurement Method

Task No.: RI-13

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones							⇧		1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			200	200	50			450
	Field Test					100			100
	Evaluation								
	Promulgation								
Totals				200	200	150			550

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

3. MEASUREMENT TECHNIQUES TO IDENTIFY AND QUANTITATE AIR POLLUTANTS

3.1 Ambient Air Quality Measurement

3.1.1 Introduction

Ambient air may be defined as the atmosphere in our immediate surroundings. The quality of this ambient air is a function of a variety of natural and man-made conditions. Solids, liquids and gases continuously cycle into and out of the atmosphere at different concentrations and rates. The atmosphere inherently contains many dispersed materials from natural sources whose concentration may vary from minute to dense. For example, plants emit oxygen, water vapor, pollen, etc.; animals emit CO_2, NH_3 and other low molecular weight compounds; and from natural episodes such as volcanic eruptions, earthquakes and storms high concentrations of diverse solids, liquids and gases may be dispersed into the atmosphere. Above this background of naturally occurring pollutants, other pollutants enter the atmosphere as emissions from a host of discrete mobile and stationary sources.

Wide variations in ambient air quality exist in different regions of the Nation as a result of differing local emissions and the presence of geographic formations and meteorological conditions which enhance or hinder the dispersive forces of the atmosphere. This section of the report is concerned with the analytical methods and instruments which will be required to measure the ambient air quality level throughout the United States.

3.1.2 Specific Requirements by Pollutant

3.1.2.1 SO_2 and Sulfur Compounds

Sulfur dioxide is the gaseous pollutant most frequently measured, and the development of measurement methods for this pollutant is correspondingly relatively well advanced. A manual measurement technique for SO_2

based on the pararosaniline method has been collaboratively tested by EPA and promulgated as the measurement method in the Federal Register of April 30, 1971. No further work on an analytical method for SO_2 is anticipated. The various instruments available do not give identical results. This situation creates a need for evaluation of commerically available instrumental procedures which can be promulgated as official measurement methods.

TASK REQUIRED: Develop and evaluate an instrumental method for continuous measurement of SO_2. (IQA-1)

Research and development is needed for simple non-wet chemical instrumental methods, for 24-hour cumulative sampling and measurement of SO_2.

TASK REQUIRED: Develop and evaluate an instrument for 24-hour cumulative sampling and analysis of SO_2. (IQA-2)

The recently developed flame photometric detector (FPD) can measure all types of volatile sulfur compounds in the atmosphere, over a wide range of concentrations, from 1 ppb to 10 ppm. It detects photometrically the emission of atomic sulfur formed during controlled combustion in a hydrogen-rich flame. This can be used directly to measure total gaseous sulfur compounds, or coupled with GC to analyze separately for H_2S, RSH, RSR or SO_2 in admixtures. The FPD method will probably be acceptable as an interim

Task Title: Develop and Evaluate an Instrumental Method for Continuous Measurement of SO_2

Task No.: IQA-1		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones			▲	⇧	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		100	50					150
	Field Test			50					50
	Evaluation				75				75
	Promulgation				5				5
Totals			100	100	80				280

▲ Date Capability Initially Required ⬆ Evaluated Method available
⇧ Interim Method Available

Task Title: Develop and Evaluate an Instrument for 24 Hour Cumulative Sampling and Analysis of SO_2

Task No.: IQA-2		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones			▲	⇧	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		75	75					150
	Field Test			50	50				100
	Evaluation				75				75
	Promulgation				10				10
Totals			75	125	135				335

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

method for total sulfur, as soon as field tests to determine its limitations are completed, and the full procedure promulgated later as the official EPA method after further work and evaluation tests.

> TASK REQUIRED: Develop and evaluate instrumental methods for total gaseous S compounds and for specific sulfur-containing compounds. (IQA-3)

H_2S is a specific pollutant that is often a local nuisance and the development of a simple means for its measurement in the ambient air is justified. The method can be cumulative but should be sensitive enough to permit measurements in time intervals as short as 1-hour.

> TASK REQUIRED: Develop and evaluate a manual method for 1-hour or less cumulative sampling and measurement of H_2S. (IQA-4).

A rapid method to determine molecular sulfuric acid (sulfuric acid mist) currently does not exist. The development of a rapid manual method, most likely based on cumulative sampling, is required to support planned EPA community studies.

> TASK REQUIRED: Develop a manual method for molecular H_2SO_4 (sulfuric acid mists). (IQA-5).*

*Asterisk indicates task sheet carried over to next page.

Task Title: **Develop and Evaluate Instrumental Methods for Total Gaseous S Compounds and for Specific Sulfur-Containing Compounds**

Task No.: IQA-3		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones				⇧	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		75	75					150
	Field Test			50					50
	Evaluation				75				75
	Promulgation				10				10
Totals			75	125	85				285

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Develop and Evaluate A Manual Method for 1-Hour Or Less Cumulative Sampling and Measurement of H_2S**

Task No.: IQA-4		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones				⇧ ⬆					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		100						100
	Field Test			50					50
	Evaluation			50					50
	Promulgation			10					10
Totals			100	110					210

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

3.1.2.2 Particulates

Particulates include fumes, mists, smog, aerosols, sprays, as well as smokes and dust, and they can be composed of almost any material. Particulate size distribution, chemical composition, and physical properties, such as density, shape, surface area and reflectance are all highly variable. Conventional methods of ambient air total particulate mass loading measurement have used either the high volume samplers for cumulative sampling or the tape samplers for rapid measurement.

Tape samplers have been promulgated as an interim method for measurement of total particulates and are in widespread use at the present time. This method is currently not acceptable as an official EPA measurement method because of several problems, chief among which has been the effect of particle color and surface reflectance on the photometric measurement of spot loading on the tape. A development program to apply alternate methods for the measurement of particulate collected on the tape, such as beta-gauging, should be undertaken to upgrade the tape sampler pending development of improved techniques for the hourly measurement of total particulate mass loading.

TASK REQUIRED: Develop beta-gauging techniques to replace the photometric measurement of particulates collected on the tape sampler. (IQA-6)

Task Title: Develop A Manual for Molecular H_2SO_4 (Sulfuric Acid Mists)

Task No.: IQA-5		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research		50						50
	Development			100					100
	Field Test			50					50
	Evaluation				75				75
	Promulgation				10				10
Totals			50	150	85				285

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop Beta-Gauging Techniques To Replace The Photometric Measurement of Particulates Collected On The Tape Sampler

Task No.: IQA-6		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		75						75
	Field Test			50					50
	Evaluation				50				50
	Promulgation				5				5
Totals			75	50	55				180

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

TASK REQUIRED: Develop and evaluate an improved instrumental method to measure hourly particulate total mass loading. (IQA-7)

Modern Hi-Vol equipment for cumulative total particulates has been greatly improved by providing measurement devices and controls for a continuous flow rate of air. A preliminary description of this equipment and its proper operation was set forth in the Federal Register for January 30, 1971. A collaborative user evaluation of the high volume sampler method has recently been completed. There are still a number of problems to be solved, however, one of which is the changing efficiency of filtration for variously-sized particles during a 24-hour period, as the filter becomes partially coated in use. Operation is affected by humidity, temperature changes, and chemical interactions of the material collected.

Many of these effects have been attributed to the fact that no currently available Hi-Vol filter medium is completely satisfactory. The development of a temperature- and humidity-stable filter medium with good mechanical properties and high collection efficiency which can be easily manufactured in large, uniform quantities is required. It should be ashless for the chemical analysis of particulate composition. This task is judged to need only a modest investment, particularly at the R/D stage, in view of its considerable commercial potential.

Task Title: Develop and Evaluate An Improved Instrumental Method To Measure Hourly Particulate Total Mass Loading

Task No.: IQA-7

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧		⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Research		50						50
	Development			150	100				250
	Field Test			50	50				100
	Evaluation					100			100
	Promulgation					10			10
Totals			50	200	150	110			510

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

TASK REQUIRED: Develop an improved filter medium for use in cumulative measurement of total particulate mass by Hi-Vol equipment. (IQA-8)

It is recognized that alternate methods, for example, staged filtration or completely different equipment such as large-scale impingers may be developed which will also meet the requirement of providing samples for further analysis. As a contingency a program to evaluate revised instrumental methods for cumulative particulate mass loading is included.

TASK REQUIRED: Field test and evaluate improved techniques for instrumental measurement of cumulative particulate mass loading. (IQA-9)

Particle size measurements have become increasingly important with the realization that the physical, chemical and biological effects of particulates all vary with particle size, and are generally greater for smaller particles. At the same time, the increasing efficiency of dust collecting devices in industry is increasing the relative amount of total particulates which are in these smaller sizes. A variety of cascade samplers are available on the market which are claimed to give satisfactory performance in the larger size range, down to about 1.0 or 0.5 microns. These are ready

Task Title: **Develop an Improved Filter Medium for Use in Cumulative Measurement of Total Particulate Mass By Hi-Vol Equipment**

Task No.: IQA-8	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧				1972 to 1977
	Funding Required ($1000's)							
Activities: Research								
Development			75	75				150
Field Test				50				50
Evaluation								
Promulgation								
Totals			75	125				200

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Field Test and Evaluate Improved Techniques for Instrumental Measurement of Cumulative Particulate Mass Loading**

Task No.: IQA-9	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	⬆			1972 to 1977
	Funding Required ($1000's)							
Activities: Research								
Development								
Field Test			50	50				100
Evaluation					50			50
Promulgation					5			5
Totals			50	50	55			155

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

for field testing, to select a preferred procedure for evaluation and promulgation as an official method for the routine collection of fractionated samples.

TASK REQUIRED: Test and evaluate commercial instruments for size distribution of suspended particulates. (IQA-10)

The smallest particles below 1 micron in size are not completely measured by present methods of sample collection. They are an important part of the "respirable particulates". These range in size from an upper limit of about 2 microns, which is not filtered out on breathing, to a lower limit of about 0.1 microns, below which the particles inhaled tend to remain suspended and escape from the lungs again on exhalation. New methods are needed which are capable of measuring the total amount of respirable particulates, either as a single measurement or in several stages. Possibilities for the smaller particles include light scattering using laser beams, centrifugal separation with or without size classification, and the measurement of pulse size as a function of particle size in pulse flame ionization.

TASK REQUIRED: Develop new instrumental techniques for respirable particulates, including the smaller particles of 0.1 to 2 micron size. (IQA-11)

The effect of particulates on visibility is important for aesthetic values, and frequently for practical purposes as well. Visibility is

Task Title: Test and Evaluate Commercial Instrument for Size Distribution of Suspended Particules

Task No.: IQA-10

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones					⇧				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			50					50
	Field Test				75				75
	Evaluation								
	Promulgation								
Totals				50	75				125

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop New Instrumental Techniques for Respirable Particulates, Including the Smaller Particles of 0.1 to 2 Micron Size

Task No.: IQA-11

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones						⇧	⬆		1972 to 1977
		Funding Required ($1000's)							
Activities	Research			100					100
	Development				100	200			300
	Field Test					50	75		125
	Evaluation						100		100
	Promulgation						10		10
Totals				100	100	250	185		635

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

usually measured over long distances, often in a particular direction. Its measurement may be affected by special effects such as light reflection or diffraction. Equipment now available includes integrating nephelometers which are ready to be field tested, in comparison with optical transmission and visual observation. Correlations should also be established with other measureable properties of the particles present. This should be followed by evaluation on a selected procedure prior to promulgation as an official method.

TASK REQUIRED: Field test and evaluate available instruments to measure visibility. (IQA-12)

Manual methods are required to determine the composition of collected particulate samples. It is expected that these analyses will be done using available laboratory techniques such as emission spectroscopy, atomic absorption, etc. Some additional development work will be required to adapt these techniques to the concentration levels that are encountered in air pollution studies.

TASK REQUIRED: Develop and evaluate laboratory methods for determining the composition of collected particulate matter. (IQA-13)

3.1.2.3 Carbon Oxides

Carbon monoxide is present in nature at very low levels, below 1 ppm, and recent data indicate that its appearance and disappearance in nature are related to the biochemistry of the oceans and of soil. The

Task Title: **Field Test and Evaluate Available Instruments to Measure Visibility.**

Task No.: IQA-12

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones				⇧	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		50						50
	Field Test			75					75
	Evaluation				75				75
	Promulgation				10				10
Totals			50	75	85				170

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Develop and Evaluate Laboratory Methods for Determing the Composition of Collected Particulate Matter**

Task No.: IQA-13

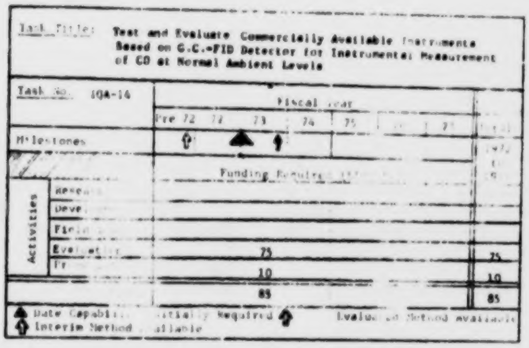
		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones					⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			75	75				150
	Field Test				75				75
	Evaluation								
	Promulgation								
Totals				75	150				225

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

usual concentration range for air measuring instruments is 0-50 ppm (0-56 mg./m^3). This requires different instruments than those best suited for much higher concentrations, in the range of 0.1% or more, which are commonly encountered in source measurements. The measurement of CO by non-dispersive infrared (NDIR) was specified in the Federal Register for April 30, 1971. A collaborative evaluation of this method has been recently completed. However, this method is sensitive to both temperature and moisture changes, and calibration becomes increasingly difficult at very low levels. While these problems can be minimized by careful controls, alternate methods which will avoid them are needed for routine measurement of ambient level trends.

The combination of gas chromatography and a flame ionization detector is giving useful results in this range. The system measures both CO and methane, in the range of 0.1 to 100 ppm. It operates by catalytically reducing CO in a portion of the gas stream to methane, after interfering gases are removed. The equipment has been field tested and is available from several manufacturers. It is now ready for evaluation, to define its limitations and preferred operating conditions, as an official method.

TASK REQUIRED: Test and evaluate commercially available instruments based on the gas chromatograph with FID detector for instrumental measurement of CO at normal ambient levels. (IQA-14)



Task Title: Test and Evaluate Commercially Available Instruments Based on G.C.-FID Detector for Instrumental Measurement of CO at Normal Ambient Levels

Task No. IQA-14

	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Total
Milestones	⇧		▲ ⬆					
Funding Required								
Activities: Research								
Devel.								
Field								
Evaluation			75					75
Pr			10					10
			85					85

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Improved CO measurement methods are in various stages of development. These include modifications to NDIR such as the use of fluorescence resonance radiation light sources by Arkon, and a German technique sensitive at very low levels in which mercuric oxide is reduced by CO to elemental mercury, which is then detected by atomic adsorption. It is assumed that within a period of about two years some of these alternates may have established a position in the instrument market, because of their simplicity. When this occurs, a further program of evaluation tests may be required to establish an improved method.

TASK REQUIRED: Field test alternate methods of ambient level CO measurement and conduct evaluations as soon as developments appear to justify an alternate official method. (IQA-15)

Research is desirable to develop and standardize a simple instrumental method for cumulative sampling and measurement of CO.

TASK REQUIRED: Develop simple instrumental methods for cumulative sampling and measurement of CO. (IQA-16)

3.1.2.4 Nitrogen Oxides (NO_x)

The Saltzman (colorimetric) method as modified by Jacobs/Hochheiser is the most widely accepted analytical method for measurement of NO_2 and this procedure has been promulgated as an interim method for ambient air analysis. A user evaluation remains to be completed.

Task Title: **Field Test Alternate Methods of Ambient Level CO Measurement and Conduct Evaluations as Soon as Developments Appear To Justify An Alternate Official Method**

Task No.: IQA-15		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	▲				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			30					30
	Field Test			50					50
	Evaluation				75				75
	Promulgation				10				10
Totals				80	85				165

▲ Date Capability Initially Required ⇧ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Develop Simple Instrumental Methods for Cumulative Sampling and Measurement of CO**

Task No.: IQA-16		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧ ▲				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		75	75					150
	Field Test				50				50
	Evaluation				50				50
	Promulgation				10				10
Totals			75	75	110				260

▲ Date Capability Initially Required ⇧ Evaluated Method Available
⇧ Interim Method Available

TASK REQUIRED: Evaluate the Jacobs-Hochheiser modified Saltzman manual method for NO_2. (IQA-17)

Considerable controversy still surrounds the adequacy of the Jacobs -Hochheiser modifed Saltzman method, for ambient measurement of NO_2. Research and development of alternate analytical techniques for NO_2 measurement should continue until a truly acceptable analytical method is developed.

TASK REQUIRED: Conduct research and development leading to an improved analytical method for ambient NO_2. (IQA-18)

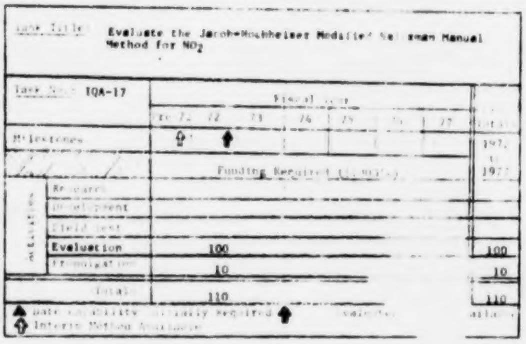
Several commercial instruments are available for colorimetrically determing NO_2. These techniques also allow measurement of NO_x ($NO + NO_2$) by adding ozone or by passing the gas sample through a filter (Cr_2O_3) to oxidize the NO to NO_2. Alternate instruments that are under development as a replacement for the colorimetric method include techniques based on electrochemistry, flame photometry and spectroscopy.

TASK REQUIRED: Complete the development of instruments for the continuous measurement of NO_2. (IQA-19) *

Further research is also desirable to develop and standardize a much simpler method for cumulative sampling and measurement of NO_2, possibly using a solid adsorbent or plug-in sensor cell.

TASK REQUIRED: Develop simple instrumental methods for cumulative sampling and measurement of NO_2. (IQA-20)*

***Asterisk indicates task sheet carried over to next page.**



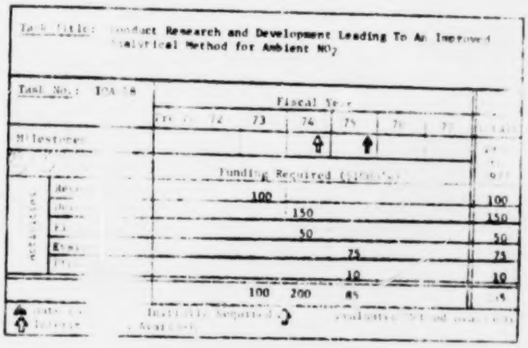
Task Title: Evaluate the Jacob-Hochheiser Modified Saltzman Manual Method for NO_2

Task No.: IQA-17

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones		⇧	⬆						1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test								
	Evaluation		100						100
	Promulgation		10						10
	Total		110						110

⬆ Date Capability Initially Required ⬆ Evaluated ... Available

⇧ Interim Method Available



Task Title: Conduct Research and Development Leading To An Improved Analytical Method for Ambient NO_2

Task No.: IQA-18

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones					⇧	⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Res...			100					100
	[illegible]				150				150
	[illegible]				50				50
	[illegible]					75			75
	[illegible]					10			10
				100	200	85			[illegible]

⬆ Date ... Initially Required ⬆ Evaluated ... and ...

⇧ Interim ... Available

The measurement of NO is important because the NO_x emitted by combustion sources and automobiles is predominantly NO. This is subsequently (and reversibly) converted to NO_2 by the action of sunlight and air, over a period of time which may be hours or days. NO has been analyzed for years by converting it first to NO_2, and new methods such as ozone titration (gas phase) and flame photometry are just now being developed. These methods are promising, but they require further development and field testing before they can be designated as official measurement methods. Instrumental methods for continuous measurement and for cumulative sampling and analysis are required.

TASK REQUIRED: Complete development and evaluate instrumental methods for continuous measurement of NO. (IQA-21)

TASK REQUIRED: Develop and evaluate instruments for cumulative sampling and analysis of NO. (IQA-22)

Task Title: **Complete the Development of Instruments for the Continuous Measurement of NO_2**

Task No.: IQA-19		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones				▲ ⇧	⬆				
		Funding Required ($1000's)							
Activities	Research								
	Development		100	100					200
	Field Test			50	50				100
	Evaluation				75				75
	Promulgation				10				10
Totals			100	150	135				385

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Develop Simple Instrumental Methods for Cumulative Sampling and Measurement of NO_2**

Task No.: IQA-20		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones					⇧	⬆			
		Funding Required ($1000's)							
Activities	Research								
	Development		75	75					150
	Field Test				50				50
	Evaluation				50				50
	Promulgation				10				10
Totals			75	75	110				260

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Complete Development and Evaluate Instrumental Methods for Continuous Measurement of NO**

Task No.: IQA-21		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones				⇧	⬆				
		Funding Required ($1000's)							
Activities	Research								
	Development		75						75
	Field Test			50					50
	Evaluation			75					75
	Promulgation			10					10
Totals			75	135					210

▲ Date Capability Initially Required ⇧ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Develop and Evaluate Instruments for Cumulative Sampling and Analysis of NO**

Task No.: IQA-22		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones					⇧	⬆			
		Funding Required ($1000's)							
Activities	Research								
	Development		50	100					150
	Field Test				50				50
	Evaluation				50				50
	Promulgation				10				10
Totals			50	100	110				260

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

A method for the determination of free nitric acid as a vapor or mist is needed.

TASK REQUIRED: Develop analytical methods for ambient molecular HNO_3. (IQA-23)

3.1.2.5 Ozone and Oxidants

Oxidants are widespread air pollutants for which National Air Quality Standards have been issued. The KI method has been issued (April 30, 1971) in the Federal Register as an interim standard method for the determination of total oxidants (TOX) and ozone in ambient air. A large number of other instruments and techniques are in use, and there is an apparent need to establish correlations between the KI method and at least some of the other methods in common use. An ozone measurement technique based on the chemiluminescence of ethylene and ozone appears to have considerable promise but still requires evaluation and promulgation as an alternate measurement technique for TOX.

TASK REQUIRED: Evaluate the KI instrumental method for total oxidants and correlate the measured TOX values with values obtained by the other oxidant and ozone measurement methods now in use. (IQA-24)

TASK REQUIRED: Evaluate an ozone instrument, as an alternate official method for "total oxidants". (IQA-25)*

Task Title: **Develop Analytical Methods for Ambient Molecular HNO_3**

Task No.: IQA-23

Fiscal Year		Pre 72	72	73	74	75	76	77	Totals 1972 to 1977
Milestones				⇧	⬆				
	Funding Required ($1000's)								
Activities	Research								
	Development		50	50					100
	Field Test			50					50
	Evaluation				50				50
	Promulgation				10				10
Totals			50	100	60				210

▲ Date Capability Initially Required ⬆ Evaluat[illegible]able
⇧ Interim Method Available

Task Title: **Evaluate the KI Instrumental Method for Total Oxidants and Correlate the Measured TOX Values with Values Obtained by the Other Oxidant and Ozone Measurement Methods Now in Use.**

Task No.: IQA-24

Fiscal Year		Pre 72	72	73	74	75	76	77	Totals 1972 to 1977
Milestones		⇧		⬆					
	Funding Required ($1000's)								
Activities	Research								
	Development								
	Field Test		50						50
	Evaluation			100					100
	Promulgation			10					10
Totals			50	110					160

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

A simple device for cumulatively sampling and analyzing oxidants or ozone is needed, such as an exposure plate or indicator tubes.

TASK REQUIRED: Develop and evaluate a simple instrumental device for cumulative sampling and analyzing total oxidants or ozone. (IQA-26)

3.1.2.6 Organic Compounds

Hydrocarbons in air are significant as a source of photochemical oxidants. This class of pollutants comprises straight and branched chain paraffins, olefins and other unsaturates, aromatics, cyclic, polycyclic, and chlorinated aliphatic and aromatic (polychlorinated biphenyl PCB) compounds. It also includes alcohols, aldehydes, esters, heterocyclic compounds, most solvents, and any volatile organic materials. Also included is polycyclic organic matter (POM) which is recognized as carcinogenic.

The measurement of total hydrocarbon is a common ambient air quality measurement. This measurement can be made using the sensitive flame ionization detector (FID) which detects any compound having a carbon-hydrogen bond. Methane is a special problem since it is present in normal ambient air, in an amount of about 1.2-1.5 ppm. This level may be 60% or more of the total hydrocarbons in the ambient air, even in an industrial environment. Accordingly, it is important to define an official method to determine non-methane hydrocarbons. A commercial instrument based on the

Task Title: **Evaluate an Ozone Instrument as an Alternate Official Method for "Total Oxidants"**

Task No.: IQA-25		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones		⇧		⬆					
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test								
	Evaluation			100					100
	Promulgation			10					10
Totals				110					110

⬆ Date Capability Initially Required ⇧ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Develop and Evaluate a Simple Instrumental Device for Cumulative Sampling and Analyzing Total Oxidants or Ozone**

Task No.: IQA-26		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones					⇧	⬆			
		Funding Required ($1000's)							
Activities	Research								
	Development			100	50				150
	Field Test				50				50
	Evaluation					75			75
	Promulgation					10			10
Totals				100	100	85			285

⬆ Date Capability Initially Required ⇧ Evaluated Method Available
⇧ Interim Method Available

combination of a gas chromatograph and the FID is available for this purpose but requires evaluation. (See also IQS-25)

TASK REQUIRED: Evaluate the GC-FID instrumental method for determination of total hydrocarbons above methane. (IQA-27)

Useful distinctions between different groups of hydrocarbons using the FID can be made in numerous ways. Substractive adsorbants can separately remove olefins or aromatics, and selective precombustion can give an indication of total hydrocarbons most reactive to oxidation. The combination of temperature programmed GC and FID is considered most promising. A simple procedure using parallel GC columns for different type measurements has been worked out and is to be field tested in the State of Pennsylvania, to distinguish methane, ethane, ethylene, acetylene, CO, and other low molecular weight hydrocarbons. At the same time, significant improvements may be possible in the FID procedure itself, including adjustments of flow sensitivity or the elimination of expensive flow regulators by generating electrolytic hydrogen and oxygen.

TASK REQUIRED: Develop modifications of the GC-FID instrumental method for specific hydrocarbons. (IQA-28)

While all hydrocarbons and their derivatives are reactive in the formation of photochemical oxidants, some hydrocarbons are more reactive

Task Title: **Evaluate the G.C.-FID Instrumental Method for Determination of Total Hydrocarbons Above Methane**

Task No.: IQA-27		Fiscal Year						Totals
		Pre 72	72	73	74	75	76	77
Milestones		⇧		⬆				1972 to 1977
		Funding Required ($1000's)						
Activities	Research							
	Development							
	Field Test							
	Evaluation			75				75
	Promulgation			10				10
	Totals			85				85

▲ Date Capability Initially Required ⇧ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Develop Modifications of the G.C.-FID Instrumental Method for Specific Hydrocarbons**

Task No.: IQA-28		Fiscal Year						[illegible]
		Pre 72	72	73	74	75	76	77
Milestones					⇧	⬆		1972 to 19..
		Funding Required ($1000's)						
Activities	Research							
	Development			100	100			[illegible]
	Field Test				50			[illegible]
	Evaluation					25		25
	Promulgation					10		10
	Totals			100	150	85		135

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

than others. This reactivity may vary between hydrocarbons, depending on the amount of other gases present such as NO_x or other oxidants. In general, the most reactive hydrocarbons present are branched olefins. There is an increasing interest in the measurement of "reactive hydrocarbons" in areas where smog is a problem, and a routine procedure is desired which will measure "reactive hydrocarbons" as a class.

TASK REQUIRED: Develop and evaluate instruments for the measurement of reactive hydrocarbons as a class. (IQA-29)

Aldehydes are important in air at the level of 1 to 200 ppb, both because of odor and because of their reactivity toward oxygen leading to peroxides. A great deal of effort has been spent in trying to adapt wet chemical methods for routine use in the field for aldehydes at this concentration level. These efforts have not been successful, although there are a number of such methods available which have the required sensitivity under laboratory conditions. The most promising instrumental method at present appears to be IR spectroscopy; derivative UV or polarography are also possibilities; however, further development and evaluation tests are needed.

TASK REQUIRED: Develop and evaluate instrumental methods to routinely measure aldehydes. (IQA-30)

The polycyclic aromatic materials (POM) of primary concern as carcinogens in air are chiefly fused ring hydrocarbons. These are found in the tar fractions of coal smoke, cigarette smoke and automobile exhaust. This aromatic tar is a product of incomplete combustion.

Task Title: Develop and Evaluate Instruments for the Measurement of Reactive Hydrocarbons As a Class

Task No.: IQA-29		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones						⇧	⬆		1972 to 1977
		Funding Required ($1000's)							
Activities	Research		75						75
	Development			100	150				250
	Field Test					50			50
	Evaluation					75			75
	Promulgation						10		10
Totals			75	100	150	125	10		460

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop and Evaluate Instrumental Methods to Routinely Measure Aldehydes

Task No.: IQA-30		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones						⇧	⬆		1972 to 1977
		Funding Required ($1000's)							
Activities	Research		50						50
	Development			150	100				250
	Field Test				50				50
	Evaluation					75			75
	Promulgation						10		10
Totals			50	150	150	75	10		435

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

The usual procedure in analysis has been to identify one or more compounds which are known to be carcinogens, chiefly benz-a-pyrene (BaP). The measurement of POM is commonly made on an extract of particulates, although some of it is present as vapor in the air. Extraction with cyclohexane appears to give a more representative sample than extraction with benzene, and adsorption or absorption methods are being investigated for total sampling from air. The preferred method of detection uses chromatography to concentrate from the extract a fraction which is examined by UV absorbance or by spectrofluorimetry. Good research results have been obtained by thin layer chromatography, and liquid-solid columns when an analysis for additional POM's is desired. Present indications are that gas chromatography can give a more rapid and selective separation for the rountine analysis of BaP or selected other carcinogens. Present procedures need to be field tested. An interim manual method can be issued based on current techniques.

TASK REQUIRED: Evaluate available test procedures for an interim manual method for analysis of benz-a-pyrene. (IQA-31)

Continuing research to lead to an automated instrument must depend in part on concurrent developments in cancer research to decide whether the measurement of BaP with or without other specific POM's is most useful for purposes of controls. It is now possible to develop a

Task Title: Evaluate Available Test Procedures for an Interim Manual Method for Analysis of Benz-a-Pyrene

Task No.:	IQA-31	Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		50						50
	Field Test			75					75
	Evaluation								
	Promulgation								
Totals			50	75					125

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

single discrete peak for BaP itself from an extract of particulates, using GC and a mixed substrate column based on sodium chloride and SE 30 on Chromosorb G. This method is simple enough for direct measurement, and its development should be continued, along with alternate procedures as available, since it now appears probable that the measurement of BaP will continue to be important as an official method.

TASK REQUIRED: Develop and evaluate automated instrumental methods for the determination of BaP. (IQA-32)

The study of methods suitable for the analysis of other POM compounds requires continuing research mainly for newly found carcinogens. Most of those now known can be measured by modification of the GC procedures and combinations already developed. Methods of identification, after preliminary separation, which are available include spectroscopy by UV, MS, IR NMR, ESR, and fluorescence. No organic compounds have been identified which are strong carcinogens outside of the broad class of POM's, but this possibility exists and must be considered if it does arise.

TASK REQUIRED: Continue development of methods for analysis of additional specific carcinogenic compounds. (IQA-33)

3.1.2.7 Halogens

Fluorides are present in ambient air in a gaseous form, and as a component of particulate matter near industrial plants which manufacture

Task Title: **Devleop and Evaluate Automated Instrumental Methods for the Determination of BaP**

Task No.: IQA-32		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧		⬆		1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			75					75
	Field Test				75				75
	Evaluation					100			100
	Promulgation					10			10
Totals				75	75	110			260

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Continue Devleopment of Methods for Analysis of Additional Specific Carcinogenic Compounds**

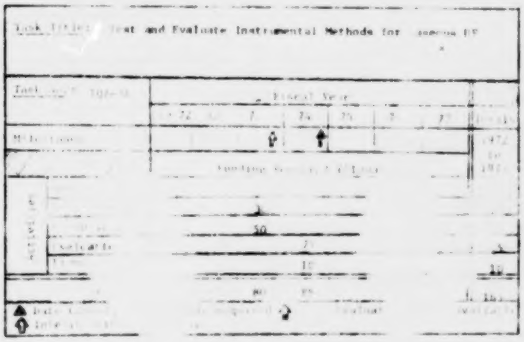
Task No.: IQA-33		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧→				1972 to 1977
		Funding Required ($1000's)							
Activities	Research			100	100				200
	Development				100	150			250
	Field Test								
	Evaluation								
	Promulgation								
Totals				100	200	150			450

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

aluminum metal, phosphate fertilizers, steel, bricks and ceramic glazes, and generally at low levels in urban areas from incineration and coal combustion. Fluorides occur most often as gaseous HF, and sometimes as SiF_4 which hydrolyzes to HF in humid air. Several methods for gaseous HF are available, and the neutral buffered specific ion electrode is considered most promising. Other possibilities include instruments based on colorimetry (Mini-Adak, Imcometer), and a micro-diffusion method. These methods are ready for testing to select a preferred method, to be evaluated for an official method.

TASK REQUIRED: Test and evaluate instrumental methods for gaseous HF. (IQA-34)

Total airborne fluorides include both gaseous HF and solid fluorides in dust particles. Some water soluble particulate fluorides are known to be harmful to vegetation and animal life. The distinction between water soluble and insoluble particulates may sometimes be of importance. Its significance lies in the fact that calcium fluoride which is water insoluble and harmless to vegetation is a major constituent, and sometimes the only fluoride present as dust. It becomes available biochemically on ingestion, at a level which has been considered as within the limits of normal animal metabolism. Present indications which are still to be confirmed are that a preferred method for total particulate fluorides


Task Title: Test and Evaluate Instrumental Methods for [illegible] HF

Task No.: [illegible]

Fiscal Year

Milestones

1972

to

197[illegible]

should include both insoluble and water-soluble fluorides. Methods are available which determine total gaseous and solid fluorides with a filter system to remove particulates, or which depend on selective wetting to separate gaseous and soluble constituents. Samples are stable enough that field collection and analysis in the laboratory is satisfactory.

TASK REQUIRED: Develop and evaluate manual methods for both water-soluble and insoluble fluoride particulates for the determination of total solid fluorides. (IQA-35)

Chlorine is chiefly of concern as an industrial hazard or as a result of local accidents but HCl may be encountered more commonly, from the incineration of plastics based on polyvinyl chloride. It can be measured reliably by conventional wet chemistry.

TASK REQUIRED: Develop and test a chlorine/HCl instrumental technique for issuance as an official instrumental method. (IQA-36)

3.1.2.8 Hazardous Air Pollutants

Qualitative identification of asbestos by means of the electron microscope presents no problems but quantitative measurement has depended on visual counting, to distinguish between asbestos and other fibers present.

An interim method is required based on the best manual procedures now available and continuing research is needed for the development of

[illegible] Develop and Evaluate Manual Methods for Both Water Soluble and Insoluble Fluoride Particulates for the Determination of Total Solid Fluorides

Task No. IQA-35

	Fiscal Year	Total 1972 to 1977
Milestones	⇧ ▲	
Funding Required ($1000's)		
Research		
Development	75	75
Field Test	50	50
Evaluation	75	75
Promulgation	10	10
Totals	[illegible] 50 85	210

▲ Date [illegible] Initially Required ⇳ Evaluated Method Available
⇧ Interim Method Available

[illegible] Develop and Test a Chlorine/HCl Instrumental Technique for Issuance as an Official Instrumental Method

Task No. IQA-36

	Fiscal Year	Total 1972 to 1977
Milestones	⇳ ▲	
Funding Required ($1000's)		
Research		
Development	100 50	150
Field Test	50	50
Evaluation	75	75
Promulgation	10	10
Totals	100 100 85	285

▲ Date Capability Initially Required ⇳ [illegible]
⇧ Interim Method Available

instrumentation. Possibilities include infrared spectroscopy and electron scanning (reflection), as well as electron diffraction which is not too selective in the presence of other fibers. The extent to which information may be needed on some other fibers should be considered during the course of the project.

TASK REQUIRED: Evaluate measurement methods based on visual counting for an interim manual method for asbestos. (IQA-37)

TASK REQUIRED: Continue research for techniques which can lead to an instrumental method for asbestos. (IQA-38)

The persistence of mercury as a cumulative toxicant from unexpectedly widely distributed sources has directed recent attention to its measurement as a hazardous chemical in ambient air as well as in other media. It is not necessary and probably not desirable to distinguish between the various forms in which mercury can be present in air. Commercial equipment is now available from several manufacturers for its measurement at the ppb level by atomic absorption, as well as by neutron activation which is more expensive but possibly more sensitive. Comparative tests of these and conventional colorimetry are needed to select a preferred method.

TASK REQUIRED: Develop and evaluate available instrumental techniques for measurement of mercury. (IQA-39)*

Task Title: Evaluate Measurement Methods Based on Visual Counting for An Interim Manual Method for Asbestos

Task No.: IQA-37	Fiscal Year: Pre 72	72	73	74	75	76	77	Totals 1972 to 1977
Milestones			⬆					
	Funding Required ($1000's)							
Activities: Research								
Development								
Field Test								
Evaluation		125						125
Promulgation			10					10
Totals		125	10					135

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Continue Research for Techniques Which Can Lead To an Instrumental Method for Asbestos

Task No.: IQA-38	Fiscal Year: Pre 72	72	73	74	75	76	77	Totals 1972 to 1977
Milestones					⇧		⬆	
	Funding Required ($1000's)							
Activities: Research			75	75				150
Development				100	200			300
Field Test					50	50		100
Evaluation						75		75
Promulgation							10	10
Totals			75	175	250	125	10	635

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Beryllium has been included in the list of hazardous air pollutants. The analysis of the solid beryllium compounds can be obtained by analysis of collected particulate samples. (IQA-13) Techniques which are well developed for this use include X-ray fluorescence, atomic absorption (flame photometry), electron emission in the UV and optical regions, microwave emissions, polarography, and anodic stripping voltammetry. If the beryllium is present as volatile materials, sample collection followed by wet chemical methods of analysis is currently required. The field testing and evaluation of these wet chemical techniques is required to promulgate an interim method.

TASK REQUIRED: Field test and evaluate currently available manual methods for volatile Be as an interim method. (IQA-40)

The development of continuous measurement techniques for volatile compounds of these pollutants should be undertaken to provide a measure of air quality levels in regions near sources which can emit these hazardous materials.

TASK REQUIRED: Develop and field test an instrument for the continuous measurement of ambient levels of volatile Beryllium (IQA-41)*

3.1.2.9 Other Pollutants

A number of other pollutants are also being considered by EPA. Manual measurement methods for many of these pollutants are required to

Task Title: **Develop and Evaluate Available Instrumental Technique for Measurement of Mercury**

Task No.: IQA-39

		Fiscal Year							Totals 1972 to 1977
		Pre 72	72	73	74	75	76	77	
Milestones				⇧	⬆				
		Funding Required ($1000's)							
Activities	Research								
	Development		50	50					100
	Field Test			50					50
	Evaluation				50				50
	Promulgation				10				10
Totals			50	100	60				210

▲ Date Capability Initially Required
⇧ Interim Method Available
⬆ Evaluated Method Available

Task Title: **Field Test and Evaluate Currently Available Manual Methods for Volatile Be As an Interim Method**

Task No.: IQA-40

		Fiscal Year							Totals 1972 to 1977
		Pre 72	72	73	74	75	76	77	
Milestones					⇧	⬆			
		Funding Required ($1000's)							
Activities	Research								
	Development		100	100					200
	Field Test				50				50
	Evaluation				75				75
	Promulgation					10			10
Totals			100	100	125	10			335

▲ Date Capability Initially Required
⇧ Interim Method Available
⬆ Evaluated Method Available

obtain data on air quality levels which could lead to future standards. Measurement of select compounds of these pollutants is provided by Task No. IQS-16.

Lead in the form of trace amounts of its alkyl derivatives and volatile inorganic halide compounds is prevalent in the ambient air of highways and urban areas, throughout the United States, as a result of the use of lead alkyls in motor fuel. (Lead is also present in various industrial dusts which are of concern in industrial hygiene, but not commonly in ambient air considerations). The preferred method for instrumental measurement is atomic absorption. Field collection followed by colorimetric analysis in the laboratory is also well developed and considered satisfactory. It is not necessary to separate specific lead compounds for analysis. An official method is needed, even though the importance of this measurement may decrease if present plans are fulfilled to convert automobiles to non-leaded fuel.

TASK REQUIRED: Develop and evaluate available manual techniques for organic and volatile inorganic Pb. (IQA-42)

Cadmium may be present in the atmosphere in the form of volatile compounds and as a component of particulate matter especially near metal coating plants and metal producing facilities. Techniques are well developed

Task Title: Develop and Field Test an Instrument for the Continuous Measurement of Ambient Levels of Volatile Berylium

Task No.: IQA-41		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones						⇧	⬆		1972 to 1977
		Funding Required ([illegible])							
Activities	Research								
	Development				150				150
	Field Test					50			50
	Evaluation								75
	Promulgation								10
Totals					150	125			285

▲ Date Capability Initially Required ⬆ Eval[illegible]thod available
⇧ Interim Method Available

Task Title: Develop and Evaluate Available Manual Techniques for Organic and Volatile Inorganic Pb

Task No.: IQA-42		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones				⇧	⬆				1972 to 1977
		Funding Required ([illegible])							
Activities	Research		50						50
	Development			100					100
	Field Test			50					50
	Evaluation				75				[illegible]
	Promulgation				10				[illegible]
			50	150	85				285

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

for analysis of solid cadmium compounds in particulate and include the use of X-ray fluorescence, atomic absorption (flame photometry), electron emission in the UV and optical regions, microwave emissions, polarography and anodic stripping voltommetry. For volatile cadmium materials, sample collection followed by wet chemical methods of analysis is currently required. The field testing and evaluation of these wet chemical techniques is required to promulgate an interim method.

TASK REQUIRED: Field test and evaluate currently available manual analytical techniques for volatile cadmium (IQA-43)

Continuous measurement techniques for volatile cadmium compounds should be developed to provide a measure of air quality levels in regions near sources which can limit these pollutants.

TASK REQUIRED: Develop and field test an instrument for the continuous measurement of ambient levels of volatile cadmium. (IQA-44)

A measurement method is required for volatile compounds of toxic non-metals, specifically arsenic, selenium and phosphorous. Perhaps these elements can be most readily measured using an instrumental method similar to the flame photometric techniques developed for total sulfur measurement.

Task Title: **Field Test and Evaluate Currently Available Manual Analytical Techniques for Volatile Cd.**

Task No.: IQA-43

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones						⇧	⬆		
		Funding Required ($1000's)							
Activities	Research								
	Development			100	100				200
	Field Test					50			50
	Evaluation					75			75
	Promulgation						10		10
Totals				100	100	125	10		335

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Develop and Field Test an Instrument for the Continuous Measurement of Ambient Levels of Volatile Cadmium**

Task No.: IQA-44

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones						⇧		⬆	
		Funding Required ($1000's)							
Activities	Research								
	Development			100	150				250
	Field Test					50			50
	Evaluation						75		75
	Promulgation						10		10
Totals				100	150	50	85		385

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

TASK REQUIRED: Develop manual methods for measurement of volatile compounds of toxic non-metals i.e., arsenic, selenium and phosphorous. (IQA-45)

Measurement methods will also be required for volatile compounds of the trace metals: copper, nickel, zinc, boron, tin, lithium, chromium, vanadium, and manganese.

TASK REQUIRED: Develop manual measurement methods for volatile compounds of the trace metals. (IQA-46)

3.1.2.10 Odors

The measurement of odors is the one problem in air pollution in which the subjective response of human sensors has continued to be most important. This cannot be entirely avoided, since the sensitivity of human sensors to odors differs markedly for different individuals, or for a given individual at different times. Considerable effort has been devoted to the development of organoleptic methods which use odor panels and dilution procedures to put a quantitative value on the odor threshold, for specific odorants or types of odor in a given sample. Several different procedures have been developed in the U.S. and elsewhere (Sweden, Switzerland, U.K.). These need to be compared and evaluated to define an official method.

TASK REQUIRED: Conduct field test and evaluations leading to an official method for odor panels. (IQA-47)*

Task Title: **Develop Manual Methods for Measurement of Volatile Compounds of Toxic Non-Metals, i.e., Arsenic, Selenium and Phosphorus**

Task No.: IQA-45

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧→		⬆→		1972 to 1977
		Funding Required ($100's)							
Activities	Research								
	Development			100	150	150			400
	Field Test				50	50	50		150
	Evaluation					75	50		125
	Promulgation					10	5		15
Totals				100	200	285	105		690

▲ Date Capability Initially Required ⇧ [illegible] Evaluated [illegible]
⇧ Interim Method Available

Task Title: Develop **Manual** Measurement Methods for Volatile Compounds of the Trace Metals

Task No.: IQA-46

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	[illegible]
Milestones					⇧→		⬆→		[illegible]
		Funding Required ($100's)							[illegible]
Activities	Res								
	Deve			100	100	150			
	Fie				50	50			
	Eval					75	75		15
	Pr					10	5		1
				100	150	285	80		

▲ Date Cap[illegible] Initially Required ⬆ Evaluation Met[illegible]
⇧ Interim [illegible] Available

Odor measurements may be accomplished more conveniently by the measuring of specific odorants or combinations of odorants, rather than attempting to measure odor as such. This requires a preliminary determination of key compounds responsible for the odor to be controlled. Progress on this already has been made by organoleptic methods for several odor situations of specific interest, such as paper and pulp mills, petroleum refineries, tanneries, animal rendering plants, and soap manufacture. Odorous compounds which are common to several of these sources include reduced sulfur compounds such as mercaptans and sulfides; reduced nitrogen compounds such as alkyl amines, diamines and heterocyclic nitrogen compounds; and organic acids and aldehydes. The odor characteristic of each source is usually a complex mixture, so identification will commonly require a separation process such as GC followed by the quantitative measurement of individual compounds or groups of compounds. Measurement methods for the reduced sulfur compounds will be provided by task nos. IQA-3 and 4 and for the organic acids and aldehydes by task no. IQA-30. Instruments to measure reduced nitrogen compounds remain to be developed.

TASK REQUIRED: Develop and evaluate instruments for measurements of reduced nitrogen compounds. (IQA-48)

Task Title: Conduct Field Test and Evaluations Leading to an Official Method for Odor Panels

Task No.: IQA -47		Fiscal Year						Totals 1972 to 1977
		Pre 72	72	73	74	75	76	77	
Milestones						⬆			
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test		50	100					150
	Evaluation				150				150
	Promulgation					15			15
Totals			50	100	150	15			315

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop and Evaluate Instruments for Measurements of Reduced Nitrogen Compounds

Task No.: IQA-48		Fiscal Year							Total 1972 to 1977
		Pre 72	72	73	74	75	76	77	
Milestones					⇧		⬆		
		Funding Required ($1000's)							
Activities	Research								
	Development			150	75				225
	Field Test				50				50
	Evaluation					50			50
	Promulgation					10			10
Totals				150	125	60			335

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Continuing research will be required to correlate organoleptic measurements and general public response with the results obtained by the instrumental analysis of selected odorants in complex mixtures.

TASK REQUIRED: Continue correlation studies among odor response, odor persistence, and measured levels of specific odorants in complex mixtures. (IQA-49)

3.2 Stationary Source Emission Measurements

3.2.1 Introduction

Stationary sources of air pollution consist of permanently fixed facilities which produce air pollutants that are recognized as significant contributors to the deterioration of air quality. This section of the measurement technique development plan is concerned with the R&D tasks that are required to provide the capability necessary to meet the needs for measurement of air pollutants at these stationary sources.

The pollutant groupings discussed below cover the emissions currently designated for control under existing legislation. In addition, several areas of concern are mentioned which may require control in the future. No attempt has been made to identify all of the specific industries where the pollutants may originate. However, pollutants from specific industries are noted where appropriate, generally as examples to justify certain aspects of the measurement technique being discussed. In addition, the task

Task Title:	Continue Correlation Studies Among Odor Response, Odor Persistence and Measured Levels of Specific Odorants in Complex Mixtures								
Task No.:	IQA-49	Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones									1972 to 1977
		Funding Required ($1000's)							
Activities	Research			100	100	100			300
	Development								
	Field Test								
	Evaluation								
	Promulgation								
Totals				100	100	100			300

▲ Date Capability Initially Required ⬆ Evaluated [illegible] Available
⇧ Interim Method Available

sheets note the number of industries where the specific test method may be applied. The measurement requirements will be covered in eleven pollutant groupings: (1) sulfur oxides; (2) oxides of nitrogen; (3) total particulate mass loading; (4) visible emissions (opacity); (5) other particulate properties (including particle size, particle number and particle composition); (6) hazardous substances; (7) carbon monoxide; (8) hydrocarbons; (9) odors; (10) halogens; and (11) other pollutants. Specific task numbers will be assigned to cover the work required.

The tasks described in this section have a significantly smaller percentage of the total expenditure in the development activity than did the tasks covering ambient air quality level measurement. This difference is due to the significant market potential for stationary source emission measurement instruments; a potential which should lead to considerable expenditures on R&D by private industry*. Accordingly the EPA expenditure shown on the task sheet assumes that many of the required instruments will be developed by the instrument industry and that EPA efforts can begin at the field test activity.

3.2.2 Specific Requirements

3.2.2.1 Sulfur Oxides

Manual Methods of Analysis

Manual methods for the determination of sulfur oxides are currently available. When the sulfur emissions can be considered as sulfur dioxide the total SO_2 can be measured by reacting the SO_2 with dilute hydrogen peroxide in a bubbler to form sulfate ion. Sulfur dioxide concentration can then be indirectly determined by titrating the sulfate

*See Appendix B

ion with standard barium perchlorate. Alternately, the sulfate ion can be determined with barium chloranilate reagent releasing the highly colored chloranilate ion which is measured spectrometrically.

When the different sulfur oxides have to be discriminated, the sulfuric acid mist (molecular H_2SO_4) particulate sulfate as well as sulfur trioxide (SO_3) can be individually determined. The particulate sulfate and the molecular H_2SO_4 are captured on a glass wool filter, maintained in a heated compartment above the dew point at the effluent gas temperature. The remaining gas is allowed to pass through a heated probe and into bubblers containing 80% isopropyl alcohol to capture the SO_3 and to allow the SO_2 to pass. The glass wool filter is extracted with isopropyl alcohol and a total acid titration made to determine the amount of total acidity present. A sulfate analysis on the residue provides a measure of total sulfate. From these two measurements both the amount of particulate sulfate and the sulfuric acid mist can be determined. The SO_3 captured in the isopropyl alcohol is extracted with sulfuric acid to form sulfate ion and is indirectly analyzed in the same manner as SO_2 above.
While these methods are in use for determining emission factors from sources containing sulfur oxides, a field test and evaluation of the methods to assure their adequacy and reproducibility in the hands of representative users is needed. This is particularly true for the lower concentrations of SO_2 to be expected from controlled sources of emission.

TASK REQUIRED: Field test and evaluate manual analytical methods for determining total sulfur oxides (or the individual sulfur oxides such as particulate sulfate, sulfuric acid mist, SO_3 and SO_2) at source level concentrations. (IQS-1)*

Automated Method of Analysis

Instrumental techniques are available for the direct continuous measurement of source emission levels of sulfur dioxide. Techniques available for the measurement include: (1) nondispersive infrared absorption, (Beckman, MSA-LIRA, Bendix-UNOR); (2) ultraviolet absorption system (DuPont and Honeywell); and (3) a correlation spectrometer which uses a comparison of the absorption of the stack gas with a photographic reproduction of the SO_2 ultraviolet spectrum (Barringer). The first two instruments, the NDIR and the ultraviolet absorption are direct continuous measurement devices for making the measurement out of stack while the correlation spectrometer instrument is capable of shooting directly across a portion of the stack to obtain a spatial average of the SO_2 concentration. Other instrumental techniques available for measuring SO_2 involve the dilution of the source sample to a concentration approaching that of the ambient atmosphere and interfacing with ambient level monitoring instruments. While these instruments have been extensively used for research applications to monitor SO_2 emissions at source level concentrations, a detailed field test is only now underway at TRW under contract from EPA.

TASK REQUIRED: Complete the field test and then evaluate automated continuous monitors for SO_2 at emission sources. (IQS-2)

Task Title: Field Test and Evaluate Manual Analytical Methods for Determining Total Sulfur Oxides (or the Individual Sulfur Oxides such as Sulfate Particulates, Sulfuric Acid Mist, SO_2 and SO_3) at Source Level Concentrations*

Task No.: IQS-1		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones			⇧ ▲ ⬆						1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test		75	100					175
	Evaluation		50	100	50				200
	Promulgation			15	10				25
Totals			125	215	60				400

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* [illegible] Industry Sources

Task Title: Complete the Field Test and Then Evaluate Automated Continuous Monitors for SO_2 at Emission Sources*

Task No.: IQS-2		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones			⇧	⬆ ▲					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test		100	125					225
	Evaluation		75	200					275
	Promulgation		10	15					25
Totals			185	340					525

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

*9 Industry Sources

No continuous monitors are currently available for measuring the emission of sulfuric acid mist from stationary sources although a new source performance standard for this pollutant is currently proposed for sulfuric acid plants. Thus, development of a continuous monitor for sulfuric acid mist is required.

TASK REQUIRED: Develop and evaluate an automated monitor for sulfuric mist. (IQS-3)

3.2.2.2 Nitrogen Oxides

Manual Methods of Analysis

A manual method for measuring total nitrogen oxides (NO_x) is available. This method is based on the collection of the nitrogen oxides in a solution of dilute sulfuric acid--hydrogen peroxide. The peroxide converts the oxides of nitrogen (excepting N_2O) to nitrate ion which is then determined colorimetrically after reaction with phenol disulfonic acid (PDS). The method has been used extensively for analyzing grab samples of effluent gases to determine emission factors at uncontrolled sources. The method has been proposed as the Federal method for compliance measurements for new source performance standards. A collaborative test of the method to insure its adequacy and reproducibility in the hands of representative users is needed.

TASK REQUIRED: Evaluate PDS manual analytical method for source level concentrations of nitrogen oxides. (IQS-4)

Task Title: Develop and Evaluate an Automated Monitor for Sulfuric Mist

Task No.: IQS-3

	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	⬆			1972 to 1977
	Funding Required ($1000's)							
Activities: Research		50						50
Activities: Development			150					150
Activities: Field Test				50				50
Activities: Evaluation				50				50
Activities: Promulgation					5			5
Totals		50	150	100	5			305

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Evaluate PDS Manual Analytical Method for Source Level Concentrations of Nitrogen Oxides

Task No.: IQS-4

	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones	⇧	▲	⬆					1972 to 1977
	Funding Required ($1000's)							
Activities: Research								
Activities: Development								
Activities: Field Test								
Activities: Evaluation		75						75
Activities: Promulgation		10						10
Totals		85						85

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Future standards may require determination of nitric acid mist (molecular HNO_3) and particulate mitrate $(NO_3)^-$ from stationary sources. Manual methods for conducting these measurements must be developed to enable emission factor determinations prior to a decision on standard requirements.

TASK REQUIRED: Develop and evaluate manual methods for determining particulate nitrate and nitric acid mist from stationary sources. (IQS-5)

Automated Methods of Analysis

A number of instrumental techniques are available for continuous measurement of source emission levels of nitrogen oxides. Most of these techniques analyze directly for either NO or NO_2. A measure of total NO_x is obtained by conversion of the NO_x mixture to the particular nitrogen oxide that the instrument measures.

Techniques available for continuous out-of-stack measurement include: (1) the non-dispersive infrared analyzer (NDIR) for measuring NO (Beckman, MSA-LIRA, Bendix-UNOR); (2) the dispersive UV analyzer for NO_2 which provides a measure of total NO_x by converting the NO to NO_2 by reaction with high pressure oxygen (DuPont); (3) the electrochemical sensor for NO_2 or NO_x, with NO obtained by difference (Dynasciences, Environmetrics); and (4) the chemiluminescent detectors that measure NO or NO_2 by observing the luminescence of the reaction with O_3 and singlet

Task Title: Develop and Evaluate Manual Methods for Determining Particulate Nitrate and Nitric Acid Mist from Stationary Sources

Task No.: IQS-5

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	▲				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		50	50					100
	Field Test			50					50
	Evaluation				75				75
	Promulgation				10				10
Totals			50	100	85				235

▲ Date Capability Initially Required ⇧ Evaluated Method Available
⇧ Interim Method Available

oxygen atoms respectively (Aerochem, Ford). A continuous in-stack analyzer based on dispersive IR is also available (Environmental Data). While these instrumental techniques are available, they have not been evaluated to determine their acceptability for monitoring requirements especially with effluent concentrations and conditions representative of controlled stationary sources. A program to field test the most promising analyzers for application at combustion sources is currently underway at Monsanto Research Corporation under EPA contract.

TASK REQUIRED: Complete the field test and then evaluate automated analyzers and monitors for NO_x. (IQS-6)

3.2.2.3 Measurement of Total Particulate Mass

Manual Methods of Analysis

The manual determination of total particulate mass involves the collection and weighing of the particulate. A probe is inserted into the stack to be measured, a sample of effluent gas is withdrawn (under isokinetic conditions if necessary) and the particulate trapped either on a filter or in impingers. Normally, a liquid is placed in the impingers to increase the efficiency of trapping the fine particulates. After evaporating the trapping solvent and drying the particulate, the amount of particulate is weighed to determine the particulate content of the gas stream. While, in principle, this appears to be a simple

Task Title: Complete the Field Test and Then Evaluate Automated Analyzers and Monitors for NO_x*

Task No.: IQS-6

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones			⇧	▲ ⬆					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test		100	50					150
	Evaluation		50	50					100
	Promulgation			10	10				20
Totals			150	110	10				270

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* 3 Industry Sources

procedure, in practice exacting requirements are needed to assure a representative sample and many variations in the sampling procedure have been developed.

The first major consideration is to determine the need for an isokinetic sample. This is a sample taken with a probe in which the flow velocity in the sampling probe is equal to the flow velocity in the duct being sampled. This may be necessary because the inertia of the particles results in their following the gas flow streamlines when the particles are relatively light and moving in straight lines as their velocity increases. To insure obtaining a representative sample, one must first determine the velocity of the gas in the duct by use of a pitot tube and then adjust the flow rate in the sampling probe to obtain isokinetic conditions. The availability of a device to automatically obtain an isokinetic sample condition would facilitate the manual determination of total particulate mass.

TASK REQUIRED: Develop an automated isokinetic sampling device for use in the measurement of particulates. (IQS-7)

A number of variations of the method for determining total particulate mass loading are currently in use by different agencies concerned with particulate measurement. These variations normally reflect differences in the definition of particulate mass. Some procedures involve the

Task Title: Develop an Automated Isokinetic Sampling Devise for Use in the Measurement of Particulates

Task No.: IQS-7		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			100					100
	Field Test				50				50
	Evaluation								
	Promulgation								
Totals				100	50				150

▲ Date Capability Initially Required ⇧ Interim Method Available
⬆ Evaluated Method Available

collection of particulates at the effluent gas conditions of temperature and humidity, requiring that the particulate collection filter be maintained at stack conditions. Other procedures require that particulates be collected after the gas effluent has been cooled, so that the definition of particulate becomes that of any material which is condensable or solid at the cooled gas temperature. The proposed Federal particulate sampling methods for use with new source performance standards requires cooling of the effluent gases before their collection; therefore, the particulates measured consist of the total condensable and solid materials at the cooled temperature.

A field test and evaluation of the Federal method for determining total particulate mass is necessary. Its application to about 28 industry categories covering many different problems such as tangential flow, low concentrations and sticky particules must be examined.

TASK REQUIRED: Test and evaluate the Federal manual method for total particulate mass loading measurements. (IQS-8)

The currently proposed Federal method for determining particulate mass from stationary sources, while requiring the cooling of the effluent gases and measurement of total solid and condensable matter at a low temperature, does not provide for the dilution of the stationary source gas sample with ambient air. This dilution would normally occur on escape of the effluent gases from the stationary source stacks. Under dilution conditions the total amount of particulate which would be formed could

Task Title: Test and Evaluate the Federal Manual Method for Total Particulate Mass Loading Measurements*

Task No.: IQS-8		Fiscal Year						
		Pre 72	72	73	74	75	76	77	Totals
Milestones			⇧	▲ ⬆→					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test		100	200	200	100			600
	Evaluation			100	200	200	100		600
	Promulgation			15	25	25	25		90
Totals			100	315	425	325	125		1290

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* 28 Industry Sources

differ substantially from that obtained using the current no-dilution procedure. The availability of a dilution system which would provide a constant volume sampling arrangement for stationary sources particulate measurements will enable measurements which are more representative of the actual particulate burden to the ambient air.

TASK REQUIRED: Develop a constant volume sampling procedure which will permit the measurement of total particulate mass of stationary sources with appropriate dilution to represent the probable particulate formation of the effluent gases after leaving the stack. (IQS-9)

Automated Methods of Analysis

No instrumental methods for the measurement of total particulate mass from stationary sources are currently in wide spread use. The commercial methods which are available include (1) the piezo crystal detectors (Thermosystems, Atlantic Research), which utilize the change in vibration frequency of a quartz crystal caused by the increase in weight resulting from impaction of particulates contained in a gas onto the crystal and; (2) the paper tape samplers which enable intermittent measurements of the particulate loading to be made by observing the change in optical transmission or reflectance of the tape (Gelman, Unico, RAC). EPA has recently completed a contract with Thermosystems Inc. to evaluate

Task Title:	Develop a Constant Volume Sampling Procedure which will Permit the Measurement of Total Particulate Mass of Stationary Sources with Appropriate Dilution to Represent the Probable Particulate Formation of the Effluent Gases after Leaving the Stack								
Task No.: IQS-9		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones							⇧	⬆	1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development				200	100			300
	Field Test					100			100
	Evaluation						100		100
	Promulgation						10		10
Totals					200	200	110		510

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

available instruments for measuring total particulate mass at power plants as well as to consider the potential of new concepts in this area. The two most promising concepts identified were the piezoelectric crystals described above and the use of β-gauging. The β-gauging technique is a variation of the paper tape sampler where, instead of using light transmission or reflectance to judge the amount of particulates the absorption of a beam of β radiation provides a measure of particulate mass which is not subject to errors resulting from the reflectance of the materials which may be light or dark color. This program has been extended to cover the field evaluation on power plants of the piezoelectric and β-gauging monitors.

TASK REQUIRED: Develop and evaluate an instrument for continuous measurement of total particulate mass loading. (IQS-10)

3.2.2.4 Visible Emissions (Opacity)

Manual Methods of Analysis

The manual technique for determining plume opacity is the visual comparison with a smokeshade. The use of the Ringlemann chart for evaluation of smokeshade is admittedly subjective and this has led to its criticism by many investigators. The background sky, the location of the sun in reference to the stack plume, and the observer all play a part in influencing the apparent smoke density. The Ringlemann technique, however, has been widely accepted and repeatedly held valid by the courts.

Task Title: Develop and Evaluate an Instrument for Continuous Measurement of Total Particulate Mass Loading*									
Task No.: IQS-10		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		250	100	75				425
	Field Test			100	200	200	100		600
	Evaluation				100	200	200	100	600
	Promulgation				15	25	25	25	90
Totals			250	200	390	425	325	125	1715

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* 28 Industry Sources

Special problems have been found when one attempts to use the Ringlemann chart for evaluation of light shaded smokes. For white smoke, which is also covered under the proposed Federal visible emissions standard for new source performance standards, a special guide is required. A white smoke guide based on the use of film strips with four different shades of grey produced by application of diamond dust has been developed by EPA and will be produced in sufficient quantity for its distribution to control agencies in selected parts of the country.

TASK REQUIRED: Promulgate a manual method for visible emissions based on white smoke guides. (IQS-11)

Automated Methods of Analysis

The common method of instrumentally determining stack opacity is through the use of light extinction techniques. In these techniques, (Bailey, Rimco, Wager) the attenuation of a beam of light which is collimated across the stack is used as a measure of the opacity of the effluent gas. Several attempts have been made to relate this opacity to the Ringlemann smoke shade measurement. The state of Texas is currently using light extinction for the in-stack measurement of opacity.

The light extinction devices usually employ a fairly wide spectrum of radiation. The light attenuation should be in the response region of the photopic vision which relates to the visible

Task Title: Promulgate a Manual Method for Visible Emissions Based on White Smoke Guides*

Task No.: IQS-11		Fiscal Year							▨
		Pre 72	72	73	74	75	76	77	Totals
Milestones			⇧	▲ ⬆					
▨		Funding Required ($1000's)							1972 to 1977
Activities	Research								
	Development								
	Field Test		75						75
	Evaluation		50	100					150
	Promulgation			10					10
Totals			125	110					235

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* All Industry Sources

emission standards. The development of a transmissometer, limited to the measurement of attenuation in the photopic region, is required to enable exact opacity measurements which can be related to human observations and determinations of compliance with visibility standards.

TASK REQUIRED: Develop and evaluate a transmissometer for in-stack automated measurement of visibility of effluent plumes and relate the opacity measurement to human observations. (IQS-12)

3.2.2.5 Other Particulate Properties

In addition to measurements of gross particle effects described in the previous two sections (Total Particulate Mass Loading and Visibility), three other types of particulate measurements may be required for compliance with future source emission controls. These are (1) particle size distribution, (2) total number of particles and (3) particle composition.

Particle Size

Manual Methods of Analysis

The determination of the size distribution of the particles emitted from a stationary source can currently be done manually by inserting an appropriate classification device (i.e. Anderson or Brinks Sampler) to separate the particulate stream into a number of different size fractions prior to collecting the particulate sample. The amount of each fraction

Task Title: Develop and Evaluate a Transmissometer for In-Stack Automated Measurement of Visibility of Effluent Plumes and Relate the Opacity Measurement to Human Observations*

Task No.: IQS-12		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	⬆				1972 to 1977
▨		Funding Required ($1000's)							
Activities	Research			100[(1)]					100
	Development								
	Field Test		75	150	75				300
	Evaluation			75	150	75			300
	Promulgation			15	15	10			40
Totals			75	340	240	85			740

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

(1) Relation of measured opacity to Ringlemann observations
* 31 Industry Sources

(different size range) is then determined by procedures similar to those used in determining the total mass of particulates. These techniques are not adequate below 0.5μ and, therefore, do not provide data in the total respirable particle size range.

TASK REQUIRED: Develop a manual method for determining particle size distribution in the range 0.05 to 0.5μ. (IQS-13)

Automated Methods of Analyses

The above technique should be suitable for determining emission factors for particulate size distribution from various sources but it will probably not provide a rapid enough technique for routine monitoring of size distribution if this becomes necessary in the future.

EPA currently has a contract with the Environmental Research Corporation to construct a device to classify according to the size of the particulates and measure the mass concentration in each class. This contract is based on inertial separation of different size fractions, each size fraction then being analyzed by β-gauging to enable an intermittent measurement of particle mass versus size distribution. Another instrumental technique which is suitable for the manual determination of particle size involves the use of a electrolyte solution containing a suspension of particles. The particles must first be collected by some other means (Coulter). In this technique an electrical current is maintained in a small dimensioned orifice. Particles suspended in the electrolyte are

Task Title: Develop a Manual Method for Determining Particle Size Distribution in the Range of 0.05 to 0.5μ

Task No.: IQS-13

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧					
		Funding Required ($1000's)							1972 to 1977
Activities	Research								
	Development		100						
	Field Test			50					100
	Evaluation								50
	Promulgation								
Totals			100	50					150

▲ Date Capability Initially Required
⇧ Interim Method Available
⬆ Evaluated Method Available

forced through the orifice and each particle displaces a quantity of the electrolyte in the orifice essentially equal to its interface volume. Thus, the three dimensions of particle volume are the basis for sizing the particulate sample. This allows determination of the particle size distribution from a representative sample of the collected particulate emissions.

TASK REQUIRED: Develop and evaluate an automated sampler/analyzer to determine particle size distribution. (IQS-14)

Number of Particles

Several instrumental techniques are available for counting the number of particles in a gas sample as distinguished from the total mass of the sample. These instruments are based on the optical detection and registering of particles as small as a half micron. The instruments have adjustable discriminators to provide for gauging the gas sample into varying particle sizes which are registered in one of four different channels (Particle Technology, Sartorius).

TASK REQUIRED: Evaluate instruments to sample and analyze for the number of particles in a gas sample. (IQS-15)

Particle Composition

The determination of particle composition while not presently required as part of the particulate standards is anticipated to be required

Task Title: Develop and Evaluate an Automated Sampler/Analyzer to Determine Particle Size Distribution

Task No.: IQS-14	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧				1972 to 1977
	Funding Required ($1000's)							
Activities: Research								
Development		200	100					300
Field Test				75				75
Evaluation								
Promulgation								
Totals		200	100	75				375

▲ Date Capability Initially Required
⇧ Interim Method Available
🡅 Evaluated Method Available

Task Title: Evaluate Instruments to Sample and Analyze for the Number of Particles in a Gas Sample

Task No.: IQS-15	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧				1972 to 1977
	Funding Required ($1000's)							
Activities: Research								
Development			30					30
Field Test			50	50				100
Evaluation								
Promulgation								
Totals			80	50				130

▲ Date Capability Initially Required
⇧ Interim Method Available
🡅 Evaluated Method Available

in future standards at least for some components of the sample. Most of the heavier metals which are considered as air pollutants are found as compounds in the particulate samples.

The current manual method for determining the composition of the particulate normally involves first collecting the particulate and then subjecting the collective samples to either an atomic absorption, X-ray spectroscopy, neutron activation, or emission spectroscopy method of analysis. This method is adequate as is but rather tedious, and the following work is intended to overcome this problem. EPA has a feasibility contract with the Naval Research Laboratory to investigate the potential of X-ray fluorescence as a means for determining particulate composition. If this program is successful the intent is to follow-up with an on-stream device which would be available in prototype form by mid-1974.

TASK REQUIRED: Develop and test an on-stream analyzer for measurement of composition of particulate matter. (IQS-16)

In addition to this task the development of analytical methods for specific particulates is covered in Task No. IQS-1 (sulfates), No. IQS-7 (nitrates), and No. IQA-13 (particulate composition).

3.2.2.6 Hazardous Substances

Asbestos, beryllium and mercury were defined as hazardous pollutants in March 1971.

Task Title: Develop and Test an On-Stream Analyzer for Measurement of Composition of Particulate Matter

Task No.: IQS-16		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones							⇧		1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			100	200				300
	Field Test		75			75			150
	Evaluation								
	Promulgation								
Totals			75	100	200	75			450

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Manual Methods of Analysis

A large number of laboratory analytical methods are available in the literature for determining these hazardous pollutants. At present, none of these methods has been extensively used for determining the concentration of these hazardous substances in stationary source emissions. They cannot be considered at this time to be accepted methods of determining gaseous emissions. A thorough investigation of the available methods must be conducted and additional methods developed for pollutants or industries for which current methods are found to be unacceptable. The methods to be evaluated here are for particulate asbestos, and volatile mercury and beryllium compounds. It is not desirable to distinguish between the various forms of mercury in the air. Problems of SO_2 interference and very low levels of mercury have already been identified. Methods for beryllium compounds in particulate matter are included in IQS-16 and IQA-40A. An evaluation of these methods must also be conducted to determine their suitability for use by representative users.

TASKS REQUIRED: Evaluate manual methods of analysis for asbestos. (IQS-17)

TASKS REQUIRED: Evaluate manual methods of analysis for mercury. (IQS-18)

Task Title: Evaluate Manual Methods of Analysis for Asbestos

Task No.: IQS-17

		Fiscal Year						
		Pre 72	72	73	74	75	76	77	Totals
Milestones		▲	⇧	⬆					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test		50						50
	Evaluation			100					100
	Promulgation			5					5
Totals			50	105					155

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Evaluate Manual Methods of Analysis for Mercury

Task No.: IQS-18

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones		⇧	▲		⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test		75						75
	Evaluation			100					100
	Promulgation			5					5
Totals			75	105					180

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

TASK REQUIRED: Develop and evaluate manual methods of analysis for beryllium. (IQS-19)

Automated Methods of Analysis

No instrumental methods for the continuous monitoring of asbestos is currently available. A feasibility study for such an instrument is planned for FY 1972. If a promising technique is found, this will be followed by the construction and evaluation of a prototype instrument. No instrumental methods for the continuous monitoring of beryllium are available.

The testing and evaluation of the most promising commercially available instruments (Olin, Barringer, DuPont) for the determination of mercury are required. These instruments are based on the spectroscopic determination of elemental mercury in the ultraviolet spectrum following its chemical release from the mercury compounds present in the source effluent.

TASK REQUIRED: Evaluate automated instruments for measuring mercury emissions. (IQS-20)

TASK REQUIRED: Develop and evaluate automated asbestos emission monitors. (IQS-21)*

TASK REQUIRED: Research, develop and test automated instruments for continuous monitoring of beryllium emissions. (IQS-22)*

Task Title: Develop and Evaluate Manual Methods of Analysis for Beryllium

Task No.: IQS-19

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones		⇧	▲	⬆					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		50						50
	Field Test		50						50
	Evaluation			50					50
	Promulgation			5					5
Totals			100	55					155

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Evaluate Automated Instruments for Measuring Mercury Emissions

Task No.: IQS-20

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test			100					100
	Evaluation				50				50
	Promulgation				5				5
Totals				100	55				155

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

3.2.2.7 Carbon Monoxide

Carbon monoxide is determined by the non-dispersive infrared analysis of the effluent gas stream. This technique is applicable for manual and automated requirements. Several instruments are commercially available for this purpose (Beckman, Bendix, MSA, LIRA) and improved instruments are beginning to appear (Arkon). An evaluation of these instruments is required to determine an official method for manual and automated measurements of CO emissions from stationary sources.

TASKS REQUIRED: Evaluate available carbon monoxide instruments for manual and automated measurement. (IQS-23)

Task Title: Develop and Evaluate Automated Asbestos Emission Monitors

Task No.: IQS-21		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧		⬆		1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			100	100				200
	Field Test				50				50
	Evaluation					50			50
	Promulgation					10			10
Totals				100	150	60			310

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Research, Develop and Test Automated Instruments for Continuous Monitoring of Beryllium Emissions

Task No.: IQS-22		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones						⇧	⬆		1972 to 1977
		Funding Required ($1000's)							
Activities	Research			100					100
	Development				100	50			150
	Field Test					50			50
	Evaluation						50		50
	Promulgation						5		5
Totals				100	100	100	55		355

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Evaluate Available CO Instruments for Manual and Automated Measurement*

Task No.: IQS-23		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones			▲ ⇧	▲ ⇧	⬆ ▲				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		40						40
	Field Test		50	75					125
	Evaluation			50	75				125
	Promulgation			10	10				20
Totals			90	135	85				310

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available 1. Manual Method; 2. Instrumental Method

* 3 Industry Sources

3.2.2.8 Organic Compounds

The batch determination of total non-methane hydrocarbons from stationary source emissions can be made by combusting the effluent gas and determining the hydrocarbon content as water and carbon dioxide. While this method is acceptable as a reference method for the determination of total hydrocarbons the method is not suitable for the routine determination of stationary source effluents. The routine determination of non-methane hydrocarbons from stationary sources is based either on total hydrocarbon determination or on determining the specific chemical constituents present in the gas mixture. When one can determine hydrocarbons without differentiating the hydrocarbon types the analysis of stationary source emissions is made using either the flame ionization detector which measures the total number of hydrocarbon bonds present (Beckman, Gomak) or by the use of the non-dispersive infrared radiation which measures the total hydrocarbons by absorption in the infrared spectrum (Beckman, MSA, Bendix, LIRA).

The flame ionization detector, while an extremely sensitive hydrocarbon detector, measures only the carbon-hydrogen bonds contained in the gas stream and accordingly does not measure the total organic content of the gas, i.e., it fails to determine carbon connected to bonds other than hydrogen such as nitrogen, oxygen, or halogen. The NDIR sensitivity varies depending on the hydrocarbon present in the gas stream due to the difference in absorption of various hydrocarbons in that region of the infrared spectrum. Accordingly, it is not a completely suitable technique for determining compliance. A field test of commercially available instruments for determining hydrocarbon content in the emissions from stationary sources is needed.

TASKS REQUIRED: Test and evaluate the available commercial instruments for measuring total non-methane hydrocarbons. (IQS-24)

The identification of specific hydrocarbons is carried out by using routine gas chromatographic detectors with the flame ionization detector which is very sensitive for materials with carbon hydrogen bonds or the electron capture detector which allows the determination of organic materials containing other bonds such as: oxygen, nitrogen, or halogen. This latter method would be suitable for PCB and other similar halogens of interest.

TASKS REQUIRED: Test and evaluate gas chromatographic systems including separation columns and detectors for measuring specific organic compounds in effluent gases. (IQS-25)

Methods for determining non-methane hydrocarbons in particulate matter are included in IQA-13.

3.2.2.9 Odors

The major odors in stationary source emissions are hydrogen sulfide (H_2S), total reduced sulfur, amines, organics, acids and aldehydes. The determination of odor can be conducted either by determining the

Task Title: Test and Evaluate Available Commercial Instruments for Measuring Total Non-Methane Hydrocarbons*

Task No.: IQS-24		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones			⇧	⬆	▲				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		40						40
	Field Test		50	100					150
	Evaluation			50	100				150
	Promulgation			10	15				25
Totals			90	160	115				365

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* 6 Industry Sources

Task Title: Test and Evaluate Gas Chromatographic Systems Including Separation Columns and Detectors for Measuring Specific Organic Compounds in Effluent Gases

Task No.: IQS-25		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			150	100				250
	Field Test				100				100
	Evaluation								
	Promulgation								
Totals				150	200				350

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

response of individuals to the odor as a class or by determining the concentration of specific chemical constituents which have been previously determined to be responsible for the odor from a particular source.

The Measurement of Odor

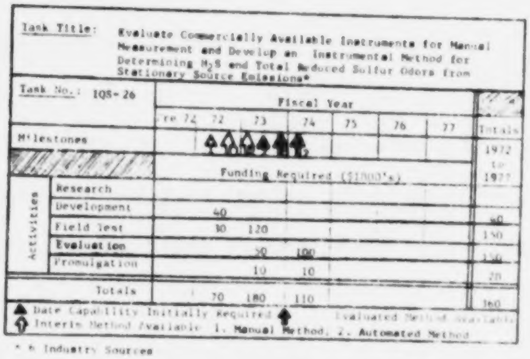
In determining the total odor from stationary source emission a grab sample of the effluent gas in the odor offending source is taken and the amount of clean diluent air required to just dilute the odor response to a human threshold level is determined. The determination of threshold response is carried out by a group of trained odor receptors known as an odor panel. This technique can be quantified by assigning odor units (O.U.) which measure the amount that the sample must be diluted to reach the threshold level. While subjective, the technique has been repeatedly upheld in the courts as a valid means for determining the amount of odor as a class from an offending source. The task required is included in IQA-47.

Determining Specific Odorants

Instrumentation is currently available to determine H_2S and total reduced sulfur component of odors by using a gas chromatographic separation column which separates the odor constituents followed by a flame photometric detector to determine low levels of sulfur containing compounds (Bendix, Melpar). When it is desirable to determine the total sulfur containing compounds in the odor source indiscriminately the determination can be conducted by first oxidizing the sulfur compounds to SO_2 and then determining the amount of SO_2 produced coulometrically (Barton). While commonly used for manual measurements, these instruments have not been fully evaulated to determine their acceptability for making compliance measurements from stationary sources emitting sulfurous odors. A fully automated instrumental system needs to be developed for monitoring purposes.

TASKS REQUIRED: Evaluate commercially available instruments for manual measurement and develop an instrumental method for determining H_2S and total reduced sulfur odors from stationary source emissions. (IQS-26)

The determination of amines, organic acids, and aldehydes which are specific odorants normally associated with rendering plants, sewage incineration facilities and petrochemical plants requires the separation of the chemical component of interest from the gas stream by using suitable gas chromatographic columns. The separated components are then measured with suitable detectors. While such techniques have been widely utilized in laboratory investigation of these particular compounds, the concentration level for the compounds have normally been far in excess of those encountered in the stationary source emissions. A thorough test and evaluation of available separation columns and detectors to determine a particular odorant and the development of additional columns as required should be undertaken to support the emission control programs in the odorant area.



Task Title: Evaluate Commercially Available Instruments for Manual Measurement and Develop an Instrumental Method for Determining H_2S and Total Reduced Sulfur Odors from Stationary Source Emissions*

Task No.: IQS-26		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones			▲ ⇧ ⇧ ▲	▲ ⬆					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		40						40
	Field Test		30	120					150
	Evaluation			50	100				150
	Promulgation			10	10				20
Totals			70	180	110				360

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available 1. Manual Method, 2. Automated Method

* 6 Industry Sources

TASKS REQUIRED: Develop tests and evaluate appropriate columns for the analysis of ammonia and amines from effluent gases to determine the specific concentration of the odorants. (IQS-27)

TASKS REQUIRED: Develop tests and evaluate commercially available separation columns for determining organic acids and aldehydes. (IQS-28)

A program to better determine the chemical constituents in the gas effluent which is responsible for odors must be conducted for those sources for which odor controls are to be promulgated in order to all the development of adequate test methodology.

TASKS REQUIRED: Determine the chemical constituents which are responsible for odors from pulp and paper mills, petroleum refineries, petrochemical plants, sewage sludge incinerators, and animal rendering plants. (IQS-29)

Task Title:	Develop Tests and Evaluate Appropriate Columns for the Analysis of Ammonia and Amines from Effluent Gases to Determine the Specific Concentration of the Odorants*								
Task No.: IQS-27		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧		⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		100						100
	Field Test			75					75
	Evaluation				25				25
	Promulgation				10				10
Totals			100	75	85				260

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* 3 Industry Sources

Task Title:	Develop Tests and Evaluate Commercially Available Separation Columns for Determining Organic Acids and Aldehydes*								
Task No.: IQS-28		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones						⇧	⬆		1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			100	50				150
	Field Test				100				100
	Evaluation					100			100
	Promulgation					15			15
Totals				100	150	115			365

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* 4 Industry Sources

Task Title:	Determine the Chemical Constituents which are Responsible for Odors from Pulp and Paper Mills, Petroleum Refineries, Petrochemical Plants, Sewage Sludge Incinerators, and Animal Rendering Plants								
Task No.: IQS-29		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones									1972 to 1977
		Funding Required ($1000's)							
Activities	Research		75	100	100				275
	Development								
	Field Test								
	Evaluation								
	Promulgation								
Totals			75	100	100				275

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

3.2.2.10 Halogens

New source performance standards planned for promulgation will include the control of emissions of various halogens from a variety of installations. Several examples follow: (1) Control of fluoride emissions from phosphate fertilizer and lime plants, and also animal feed defluorination plants, (2) Control of hydrogen chloride (HCl) from hydrochloric acid plants, (3) Control of chlorine gas (Cl_2) from chlorine and caustic plants. In addition, it is probable that future performance standards will include the control of fluoride emissions from the iron and steel industries and the control of chloride emissions from municipal incinerators.

Manual Method of Analysis

Manual methods for the analysis of halogens based on the gravimetric determination of the halogen as the silver halogen salts are available. Other techniques based on colorimetric measurement are also available. These techniques must be tested and evaluated to select suitable methods for manual measurement of gaseous halogen emissions from stationary sources.

TASKS REQUIRED: Test and evaluate the manual analytical methods for determining gaseous fluorides. (IQS-30)

TASKS REQUIRED: Test and evaluate the manual analytical methods for determining gaseous chlorides. (IQS-31)

Task Title: Test and Evaluate the Manual Analytical Methods for Determining Gaseous Fluorides*

Task No.: IQS-30		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones			▲ ⇧		⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		30						30
	Field Test		50	50					100
	Evaluation			75	25				100
	Promulgation			10	5				15
Totals			80	135	30				245

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* 4 Industry Sources

Task Title: Test and Evaluate the Manual Analytical Methods for Determining Gaseous Chlorides*

Task No.: IQS-31		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧ ▲	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		30						30
	Field Test		50						50
	Evaluation			50					50
	Promulgation			10					10
Totals			80	60					160

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* 3 Industry Sources

Automated Methods of Analysis

Colorimetric analyzers currently exist for the measurement of fluorine in the atmosphere. These methods are based on the reduction or change in coloration produced by fluorine complexes. These techniques have been automated for use as intermittent continuous analyzers for measurement of fluorine emissions (Leigh). An evaluation of this technique and the fluoride specific ion electrode (Corning, Orion) is required to provide an acceptable instrumental method for monitoring fluoride emissions.

TASKS REQUIRED: Test and evaluate the available commercial instruments for automated measurement of fluorides. (IQS-32)

The determination of hydrogen chloride can be conducted by measuring absorption in its ultraviolet spectrum (DuPont). Total chlorides (Cl^-) can be determined by use of the chloride specific ion electrodes (Corning, Orion).

TASKS REQUIRED: Test and evaluate the available commercial instruments for automated measurements of hydrogen chloride and total chlorides. (IQS-33)

Methods for the determination of halides in particulates are included in IQA-13.

3.2.2.11 Other Pollutants

Current plans call for measurement of the ambient air quality level of additional pollutants which have not yet been covered in this

Task Title: Test and Evaluate the Available Commercial Instruments for Automated Measurement of Fluorides*

Task No.: IQS-32	Fiscal Year							Totals
	Pre 72	72	73	74	75	76	77	
Milestones			⇧	▲ ⬆				1972 to 1977
	Funding Required ($1000's)							
Activities: Research								
Development		30						30
Field Test		50	50					100
Evaluation			50	50				100
Promulgation			10	10				20
Totals		80	110	60				250

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* 4 Industry Sources

Task Title: Test and Evaluate the Available Commercial Instruments for Automated Measurements of Hydrogen Chloride and Total Chlorides*

Task No.: IQS-33	Fiscal Year							Totals
	Pre 72	72	73	74	75	76	77	
Milestones				⇧	⬆ ▲			1972 to 1977
	Funding Required ($1000's)							
Activities: Research								
Development			30					30
Field Test			50					50
Evaluation				50				50
Promulgation				10				10
Totals			80	60				140

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

* 2 Industry Sources

section on stationary source emission measurements. These include cadmium and lead, the non-metals: phosphorous, arsenic and selenium; and the trace metals: copper, zinc, boron, nickel, tin, lithmium, chromium, vanadium and manganese. Cadmium and lead are special pollutants of particular concern and are thus treated in separate tasks below (IQS-34,35). Task No. IQS-16 provides for the development and evaluation of instrumentation for on-stream measurement of particulate composition from stationary sources of emission and along with Task No. IQA-13 which provides the capability for manual determination of particulate composition from collected particulate samples should suffice for measurements of solid compounds of these pollutants which may be required. As a minimum techniques to manually measure source emission levels of the gaseous compounds of these pollutants will be necessary to enable the determination of emission factors.

TASK REQUIRED: Develop manual methods for the measurement at source emission levels of gaseous compounds of cadmium. (IQS-34)

TASK REQUIRED: Develop manual methods for the measurement at source emission levels of gaseous compounds of lead. (IQS-35)

Task Title: Develop Manual Methods for the Measurement at Source Emission Levels of Gaseous Compounds of Cadmium

Task No.: IQS-34

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones						⇧			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			75					75
	Field Test				50				50
	Evaluation				50				50
	Promulgation				5				5
Totals				75	105				180

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop Manual Methods for the Measurement at Source Emission Levels of Gaseous Compounds of Lead

Task No.: IQS-35

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧	⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			50					50
	Field Test				50				50
	Evaluation				50				50
	Promulgation				5				5
Totals				50	105				155

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

TASK REQUIRED: Develop manual methods for the measurement at source emission levels of gaseous compounds of arsenic, selenium and phosphorous. (IQS-36)

TASK REQUIRED: Develop manual methods for the measurement at source emission levels of gaseous compounds of the trace metals. (IQS-37)

No task for development of automated instruments for continuous measurement of these pollutants at source emission levels is included in this plan. The need for such tasks should be considered during the next revision of this working document.

3.2.2.12 Other Tasks

Current emission standards place limitations on the mass of pollution that is emitted from a stationary source, while the manual and instrumental measurement methods provided for in this plan generally provide information only on the volumetric concentration of pollutants. In order to relate this information to mass emission rates needed to set standards and to determine compliance with the standards data on the mass flow velocity, temperature and pressure in the emitting stack is required. Pressure is relatively constant in the stack and its measurement poses no problem. Temperature and flow velocity, on the other hand, are often non-uniform across the stack and require careful

Task Title: Develop Manual Methods for Measurement at Source Emission Levels of Gaseous Compounds of Arsenic, Selenium and Phosphorous

Task No.: IQS-36

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones						⇧			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			100	100				200
	Field Test				50	50			100
	Evaluation								
	Promulgation								
Totals				100	150	50			300

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop Manual Methods for the Measurement at Source Emission Levels of Gaseous Compounds of the Trace Metals

Task No.: IQS-37

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones							⇧→		1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development				100	200	100		400
	Field Test					50	100		150
	Evaluation								
	Promulgation								
Totals					100	250	200		550

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

measurement if meaningful mass emission rates are to be obtained. Work is required to develop improved methods for determination of temperature and velocity profiles across a stack.

> TASK REQUIRED: Develop techniques for determining the temperature profile across a stack. (IQS-38)

> TASK REQUIRED: Develop techniques for determining the flow velocity profile across a stack. (IQS-39)

3.3 Moving Source Emissions Measurements

3.3.1 Introduction

Moving sources of air pollution consist of discrete sources of air pollution that are recognized as significant contributors to the deterioration of local air quality particularly in urban areas, along interstate freeways and in the vicinity of airports. In common with stationary sources of pollution, they are discrete sources but they have their own special characteristics which require special measurement tools and techniques. This section of the R&D plan is concerned with three areas of work necessary to achieve the capability to measure the emissions from moving sources: (1) measurement of emissions from motor vehicles; (2) measurement of emissions from aircraft; and (3) measurement techniques to support the fuel registration program.

Task Title: Develop Techniques for Determining the Temperature Profile Across a Stack

Task No.: IQS-38

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones					⇧	⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			100					100
	Field Test				50				50
	Evaluation				50				50
	Promulgation				5				5
Totals				100	105				205

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop Techniques for Determining the Flow Velocity Profile Across a Stack

Task No.: IQS-39

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones					⇧	⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		75	75					150
	Field Test				50				50
	Evaluation					50			50
	Promulgation					5			5
Totals			75	75	50	55			255

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

3.3.2 Motor Vehicle Emission Measurement

3.3.2.1 Sampling Motor Vehicle Emissions

The operating cycle procedures which have been developed to simulate road driving patterns of necessity involve a number of driving modes; idling, accelerating, cruising and decelerating. Each of these modes involves different concentrations of air pollutant emissions. For example, the hydrocarbon emission will range between 300 ppm and 12,000 ppm with a representative emission in the exhaust gas of some 800 ppm hydrocarbon at idle conditions and 5000 ppm during the deceleration mode. The oxides of nitrogen emissions will range between 5 and 4000 ppm in the exhaust with representative emissions being about 6 ppm in deceleration and 1500 ppm during acceleration modes. In addition to the wide variation in pollutant emission concentration during the different driving modes the exhaust volume ranges over a ratio of about 8. This involves a gas exhaust volume range between 5 standard cubic feet per minute during idling and deceleration modes to as much as 40 standard cubic feet per minute during acceleration. Exhaust gas temperature also varies between the different driving modes ranging between 150°C during idling to as high as 500°C during the acceleration cycle.

In order to obtain a representative measurement of the exhaust emission during a complete test procedure involving various combinations of these driving modes, several different sampling procedures have been utilized.

The raw gas can be sampled directly and led to the measurement device. In sampling the raw gas exhaust, three different sampling strategies can be considered. The first involves collecting these total raw emissions in a suitable container during the test cycle and analyzing an aliquot of the total collected raw emissions. This procedure while inherently simple requires that a container of suitable size be provided to collect the total raw emissions. For the 23 minute time-trace operating cycle, currently required by Federal procedures for certification testing, the container required would be enormous. In addition, this sampling strategy suffers from the disadvantage that the storage time prior to analysis of the gas can result in marked chemical changes in gas composition and the dilution of the exhaust gases normally occurring in the atmosphere is absent.

The second strategy which can be used while sampling the raw exhaust involves collecting only an aliquot of the raw emissions in the bag during the test cycle and again analyzing a portion of it at the end of the test. This has the advantage of reducing the size of the sample container necessary. It, however, also retains the same disadvantages as collecting the total raw emissions in that again the storage time results in marked chemical changes in composition and the dilution of the exhaust gases normally occurring in the atmosphere is absent. This strategy requires the use of appropriate sensors to control the proportionating sampler to insure that the collected sample is representative of the mass emission rate that is being emitted during the total driving cycle.

TASK REQUIRED: Develop and evaluate a simplified exhaust flow and/or carburetor air intake sensor to control the proportional sampling rates for use with the raw exhaust sampling system (IQM-1).

The vehicle emissions could also be determined by using continuous on-line analysis of the raw exhaust with integration of the analyzer output signals to obtain data on emissions during the test cycle. The third approach would provide information on emissions as the driving cycle changes and should be of prime usefulness in the research and development program to devise more effective control systems. Again this technique requires the development of appropriate sensors to properly weigh the analyzer output by taking account of the exhaust flow rate and temperature.

The sampling procedure currently required by EPA regulations for determining the emissions from motor vehicle sources involves the use of a constant mass sampler (CMS). This procedure insures that the total exhaust gas will have been representatively collected and automatically provides for weighting of the exhaust volume by the dilution with clear air. CMS procedure also results in dilution of the exhaust gas which more closely represents what actually occurs in the atmosphere, which of course is what one is trying to determine by the total test procedure. The procedure which is required for constant mass sampling

Task Title: Develop and Evaluate a Simplified Exhaust Flow and/or Carburetor Air Intake Sensor to Control the Proportional Sampling Rates for Use With the Raw Exhaust Sampling System

Task No.: IQM-1		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			50	50				100
	Field Test				50				50
	Evaluation								
	Promulgation								
Totals				50	100				150

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

is relatively complex. It involves the use of positive air displacement pumps that draw some 8 times the maximum exhaust flow rate of the automobile exhaust and a proportionating system to collect a small portion of this exhaust in a container for later analysis. The constant mass sampling system appears adequate for certification testing and surveillance testing of the gaseous air pollutants during the coming years. The CMS system does, however, result in a considerable dilution of the exhaust gas sample, some 8-fold average dilution;and results in a much reduced concentration of the air pollutant to be measured. Although not particularly a draw-back for measurements in the 72-74 model year time period, this will pose some instrumental capability requirements as the emission levels are continuously decreased in time for the 1976 emission standards. The constant mass sampling system can also be considered for continuous on-line analysis using integration of the analyzer output signal to obtain data on emissions during this test cycle. The use of the constant mass sampling system for potential future "on the road" surveillance testing will require a size reduction of the constant mass sampling hardware.

TASK REQUIRED: Simplify and evaluate the constant mass sampling system for potential use on-the-road to confirm the validity of the operating test cycles for measurements to determine compliance with the light duty vehicle emission standards (IQM-2).

Task Title: Simplify and Evaluate the Constant Mass Sampling System for Potential Use on-the-Road to Confirm the Validity of the Operating Test Cycles for Measurements to Determine Compliance with the Light Duty Vehicle Emission Standards

Task No.: IQM-2		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					•		⇧		1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development				100	100			200
	Field Test					50	100		150
	Evaluation								
	Promulgation								
Totals					100	150	100		350

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

The measurement of particulate total mass emitted from light duty motor vehicles although not currently specified by legislation may be required in support of standards subsequent to 1975 model year. At this time, it is still not known whether particulate emission standards will be necessary and if so whether they will involve only the total particulate mass or whether a fine particulate standard will also be promulgated following removal of lead from gasoline. Measurement techniques must be made available to enable determination of the need for particulate standards to be promulgated in mid-1975 for application to the 1977 model year vehicles. The current sampling procedure for certification testing, involving constant mass sampling with collection of an aliquot of the sample in a bag for subsequent analysis is not expected to be suitable for collection of particulates.

TASK REQUIRED: Develop and evaluate a sampling procedure for particulate total mass loading consistent with the currently accepted constant mass sampling procedure (IQM-3).

Other vehicles under control which are classified in the Federal Register as those powered by heavy duty engines and diesels. These are mainly trucks and busses. Off the road vehicles such as farm tractors, heavy earth moving equipment, and stationary generators, etc. may employ similar power sources. Fuels used in these vehicles may be either

Task Title: Develop and Evaluate a Sampling Procedure for Particulate Total Mass Loading Consistent with the Currently Accepted Constant Mass Sampling Procedure

Task No.: IQM-3		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		150	100					250
	Field Test			50	50				100
	Evaluation				100				100
	Promulgation				10				10
Totals			150	150	160				460

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

gasoline or diesel fuels similar to those used in automobiles. However, their use and operating procedures vary and thus different sampling procedures need to be developed.

TASK REQUIRED: Develop and evaluate sampling procedures to obtain representative emissions from heavy duty gasoline powered engines (IQM-4).

TASK REQUIRED: Develop and evaluate sampling procedures to obtain representative emissions from heavy duty diesel engines (IQM-5).

The nation's program for reducing air pollution from moving sources involves development of advanced automotive power plants with low emissions. One of the non-conventional power plants for potential early application to light duty vehicles is the automotive gas turbine. The turbine has exhaust flow characteristics considerably different from those of the IC engine. New sampling procedures to determine the very low levels of pollutant concentration that result from the large volume of air that is entrained by the gas turbine are required.

TASK REQUIRED: Develop and evaluate sampling procedures to obtain representative emissions from the auto gas turbine (IQM-6).*

Sampling procedures will have to be promulgated for other advanced automotive power plants as they become available. This requirement

Task Title: Develop and Evaluate Sampling Procedures to Obtain Representative Emissions from Heavy Duty Gasoline Powered Engines

Task No.: IQM-4

	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones			⬆					1972 to 1977
	Funding Required ($1000's)							
Activities: Research								
Development		75						75
Field Test			75					75
Evaluation			50					50
Promulgation			10					10
Totals		75	135					210

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop and Evaluate Sampling Procedures to Obtain Representative Emissions from Heavy Duty Diesel Engines

Task No.: IQM-5

	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones				⬆				1972 to 1977
	Funding Required ($1000's)							
Activities: Research								
Development			75					75
Field Test				75				75
Evaluation				50				50
Promulgation				10				10
Totals			75	135				210

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

will exist whether the vehicles go into production or whether one is interested only in pre-production testing of the emissions from these power plants. Many of these advanced automotive power plants will involve external heating of a working fluid which will pose a different type of emission sampling than that currently encountered with the IC engine. This is a continuing program the results of which will perhaps be initially required in the 1973 fiscal year.

TASK REQUIRED: Develop and evaluate the sampling procedures for externally heated and other advanced automotive power plants (IQM-7).

Additional air pollutants are being considered for possible motor vehicle emission regulations. These include the emission of asbestos and the emission of rubber materials during operation of the motor vehicle. Asbestos is emitted from wear of brakes and clutch facings, etc. Wear of the automobile tires are a prime source of rubber particle emissions. Since the emission of these air pollutants will be from portions of a vehicle from which measurement of air pollutants are not currently being made, different sampling procedures will be required.

TASK REQUIRED: Develop and evaluate a sampling procedure for asbestos particles emitted during operation of the motor vehicle (IQM-8).*

Task Title: Develop and Evaluate Sampling Procedures to Obtain Representative Emissions from the Auto Gas Turbine

Task No.: IQM-6

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧		⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		75						75
	Field Test			75					75
	Evaluation					100			100
	Promulgation					10			10
Totals			75	75		110			260

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop and Evaluate the Sampling Procedures for Externally Heated and Other Advanced Automotive Power Plants

Task No.: IQM-7

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧→		⬆→		1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			100	200	100	100		500
	Field Test				75	100	50		225
	Evaluation					75	100	75	250
	Promulgation						15	10	25
Totals				100	275	275	265	85	1000

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

TASK REQUIRED: Develop and evaluate a sampling procedure for rubber particles emitted during operation of the motor vehicle (IQM-9).

If sampling of new motor vehicles produced by a manufacturer is conducted at the end of the line to determine the conformance of vehicle production with the certification standards one may require different sampling procedures to be compatible with the expected operating cycle procedure which will be needed if more than a small statistical sample of the vehicle production is inspected at the end of the line. Such sampling procedures may be required in any case as technical support from the Federal government for those states such as California who are planning inspection of at least 25% of the new motor vehicles before they can be sold in the state.

TASK REQUIRED: Develop and evaluate a simplified procedure for sampling at the end of the line compatible with the end of the line operating test cycle (IQM-10).

Task Title: Develop and Evaluate a Sampling Procedure for Asbestos Particles Emitted During Operation of the Motor Vehicle

Task No.: IQM-8		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	▲ ⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		100	50					150
	Field Test			75					75
	Evaluation				75				75
	Promulgation				10				10
Totals			100	125	85				310

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop and Evaluate a Sampling Procedure for Rubber Particles Emitted During Operation of the Motor Vehicle

Task No.: IQM-9		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					▲⇧	⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			75					75
	Field Test				50				50
	Evaluation					75			75
	Promulgation					10			10
Totals				75	50	85			210

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop and Evaluate a Simplified Procedure for Sampling at the End of the Line Compatible with the End of the Line Operating Test Cycle

Task No.: IQM-10		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones			⇧		⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		75	200					275
	Field Test		50		75				125
	Evaluation				100				100
	Promulgation				10				10
Totals			125	200	185				510

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

A decision to inspect vehicles in general use will require that sampling procedures be developed for use in the state inspection of motor vehicles. This sampling could occur under a number of different operating cycle procedures ranging from measurements made at idle with the transmission in neutral to measurements made under different drive mode conditions with the vehicle physically restrained and rotating against inertia wheels to simulate the load imposed by normal driving conditions. Likewise the routine inspection of vehicles in general use could occur by spot checking vehicles at the side of the road.

TASK REQUIRED: Develop and evaluate sampling procedures to support state inspection of motor vehicles in general use where the measurement is made according to the selected operating procedure at a fixed location with inertia wheels or other appropriate devices to simulate road loading conditions (IQM-11).

TASK REQUIRED: Develop and evaluate a sampling procedure for use by the states in inspecting vehicles in general use where the measurement is made as spot checks at idle conditions (IQM-12)

The introduction of a program to determine the compliance of vehicles in general use with the automotive standards by means of a state inspection program will require that action be taken by the owners or operators of those motor vehicles which do not meet the standards. This will impose a requirement for adjustment of the vehicle engine control

Task Title: Develop and Evaluate Sampling Procedures to Support State Inspection of Motor Vehicles in General Use Where the Measurement is Made According to the Selected Operating Procedure at a Fixed Location With Inertia Wheels or Other Appropriate Devices to Simulate Road Loading Conditions

Task No.: IQM-11

	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones					⬆			1972 to 1977
Activities	Funding Required ($1000's)							
Research								
Development			200					200
Field Test				100				100
Evaluation					150			150
Promulgation					20			20
Totals			200	100	170			470

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop and Evaluate a Sampling Procedure for Use by the States in Inspecting Vehicles in General Use Where the Measurement is Made as Spot Checks at Idle Conditions

Task No.: IQM-12

	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones					⬆			1972 to 1977
Activities	Funding Required ($1000's)							
Research								
Development			100	50				150
Field Test				75				75
Evaluation					100			100
Promulgation					15			15
Totals			100	125	115			340

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

devices or systems by repair facilities to restore the vehicle to proper emitting conditions. Sampling procedures will have to be provided for the routine service station adjustment of motor vehicles.

TASK REQUIRED: Develop and evaluate simple sampling procedures for use by service stations and repair facilities to restore motor vehicles to proper emission standards (IQM-13).

3.3.2.2 Gaseous Pollutants

The gaseous pollutants emitted from mobile sources which are covered by emission standards include hydrocarbons, carbon monoxide and oxides of nitrogen. Additional classes of pollutants which are under examination for emission standards to be promulgated possibly later in the decade include particulates, fine particulates, reactive hydrocarbons, oxygenates, polycyclic organic matter, and odors. Measurement techniques for support of research studies to define emissions and set emission standards as well as for subsequent routine measurements of these various pollutants will be required to enable certification of motor vehicle engines.

Hydrocarbons

The measurement of hydrocarbons from mobile source emission exhaust is currently made by means of either the non-dispersive infrared analyzer or the flame ionization detector. The non-dispersive infrared technique seems to be more prominent in the instruments which have been developed for use with inspection procedures while the

Task Title: Develop and Evaluate Simple Sampling Procedures for Use by Service Stations and Repair Facilities to Restore Motor Vehicles to Proper Emission Standards

Task No.: IQM-13		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧	⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			100	50				150
	Field Test				75				75
	Evaluation					150			150
	Promulgation					15			15
Totals				100	125	165			390

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

federal certification procedure requires the use of flame ionization detection. The flame ionization detector measures the total amount of carbon-hydrogen bonds in the emitted gas effluent and accordingly also measures methane. The national ambient air quality standards, however, define the ambient air quality from a measurement of total hydrocarbons less methane and it is desirable to obtain comparable measurements of automotive emissions. The automotive manufacturers have requested that a similar standard be issued for mobile source emissions. A continuous analyzer for measurements of automotive exhaust which measures hydrocarbon minus methane is required.

TASK REQUIRED: Develop and evaluate a continuous analyzer for measurement of total hydrocarbon less methane from automotive exhaust (IQM-14).

It is expected that mobile sources will utilize an increasing amount of heavier distillate fuels in the years to come. This will make it necessary to perhaps include a specific emission standard on a heavy hydrocarbon from both turbine engines and from automotive engines utilizing heavy fuels. At this time, no hydrocarbon detection system is available for measurement of heavy hydrocarbons as a class.

TASK REQUIRED: Develop an analytical technique to enable research measurements to be made of heavy hydrocarbon emissions to determine if a standard for heavy hydrocarbons is required (IQM-15).

Task Title: Develop and Evaluate a Continuous Analyzer for Measurement of Total Hydrocarbon Less Methane from Automotive Exhaust

Task No.: IQM-14		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		75	75					150
	Field Test			50					50
	Evaluation				75				75
	Promulgation				10				10
Totals			75	125	85				285

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop an Analytical Technique to Enable Research Measurements to be Made of Heavy Hydrocarbon Emissions to Determine if a Standard for Heavy Hydrocarbons is Required

Task No.: IQM-15		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		75	75					150
	Field Test			50					50
	Evaluation								
	Promulgation								
Totals			75	125					200

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

TASK REQUIRED: Develop and evaluate an instrument for measurement of heavy hydrocarbons from mobile source exhaust to enable routine measurement of heavy hydrocarbons during certification and inspection procedures (IQM-16).

Carbon Monoxide

Carbon monoxide from moving sources is currently measured using a non-dispersive infrared analyzer. This instrument is acceptable for the measurement currently required under the 1972 through 1974 emission standards. However, the ten-fold reduction in carbon monoxide emission which is required by the Clean Air Amendments of 1970 for meeting the 1975 emission standards will require precision and sensitivity for the carbon monoxide detector which is beyond currently available instruments. The current carbon monoxide content of the gas sample with the CMS sampling procedure is about 1400 parts per million while the 1975 reduction in carbon monoxide emissions will result in a carbon monoxide content of about 140 parts per million if the constant mass sampling system remains in use. The Environmental Protection Agency has under contract the development of a fluorescent carbon monoxide sensor which should provide a higher degree of sensitivity than the current non-dispersive infrared instrument.

TASK REQUIRED: Complete development and evaluate an instrument for carbon monoxide with improved sensitivity for use with 1975+ standards (IQM-17).

Task Title: Develop and Evaluate an Instrument for Measurement of Heavy Hydrocarbons from Mobile Source Exhaust to Enable Routine Measurement of Heavy Hydrocarbons During Certification and Inspection Procedures

Task No.: IQM-16

	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones			⇧	⬆				1972 to 1977
	Funding Required ($1000's)							
Activities: Research								
Development		75	75					150
Field Test			50					50
Evaluation				50				50
Promulgation				10				10
Totals		75	125	60				260

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Complete Development and Evaluate an Instrument for Carbon Monoxide with Improved Sensitivity for Use With 1975 + Standards

Task No.: IQM-17

	Fiscal Year							
	Pre 72	72	73	74	75	76	77	Totals
Milestones			⇧	⬆				1972 to 1977
	Funding Required ($1000's)							
Activities: Research								
Development		75	75					150
Field Test			50					50
Evaluation				50				50
Promulgation				10				10
Totals		75	125	60				260

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Nitrogen Oxides

The Federal emissions standards require the measurement of nitrogen oxides for determining compliance with 1973 model year emission standards. Instruments that are currently available are based on the use of the chemiluminescent reaction of nitric oxide with ozone and measure only nitric oxide and not total nitrogen oxides. These instruments will probably have to be used for 1973 standards.

EPA has a program with Monsanto Research to develop a total nitrogen oxides sensor based on the reaction of NO_x with oxygen atoms. This instrument will provide a measurement capability to directly measure the total oxides of nitrogen as required by current Federal emission standards.

TASK REQUIRED: Complete the test and evaluation of routine monitors for total nitrogen oxide emissions (IQM-18).

Other Pollutants

It is possible that a national ambient air quality standard will be established for polycyclic organic matter during the planning period covered by this report. This emphasizes the importance of determining mobile source emissions of this pollutant. A research analytical method to determine polyorganic matter in automotive exhaust is currently available to enable information to be obtained which could lead to the setting of an emission standard. A routine instrument for measurement of polycyclic

Task Title: Complete the Test and Evaluation of Routine Monitors for Total Nitrogen Oxide Emissions

Task No.: IQM-18		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones			⬆						1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test		50						50
	Evaluation		75						75
	Promulgation		10						10
Totals			135						135

▲ Date Capability Initially Required
⇧ Interim Method Available
⬆ Evaluated Method Available

organic matter as a class would have to be available by early 1974 for potential application to standards which might be promulgated for 1977 or later model year vehicles.

TASK REQUIRED: Develop an instrument for routine monitoring of polycyclic organic matter from automobile exhaust (IQM-19).

Another pollutant class being considered for emission standards from mobile source exhaust is reactive hydrocarbons. This is a sub-class of total hydrocarbons which are primarily responsible for eye irritation and smog formation from auto exhaust. The initial requirement in this reactive hydrocarbon standard setting is to define the composition of the gaseous pollutants from automobile exhaust which are reactive and to define what we mean by reactivity.

TASK REQUIRED: Develop laboratory analytical methods for determining reactive hydrocarbons present in automotive emissions in support of a program to define what we mean by reactivity (IQM-20).

TASK REQUIRED: Develop the instrumental capability for routine measurement of the reactive components of auto exhaust consistent with the definition of reactivity (IQM-21).*

Additional reactive species from auto exhaust include the oxygenates, a class of compounds which contain reactive carbon

Task Title: Develop an Instrument for Routine Monitoring of Polycyclic Organic Matter from Automobile Exhaust

Task No.: IQM-19		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧	⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			100	100				200
	Field Test				50				50
	Evaluation					100			100
	Promulgation					10			10
Totals				100	150	110			360

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop Laboratory Analytical Methods for Determining Reactive Hydrocarbons Present in Automotive Emissions in Support of a Program to Define What We Mean by Reactivity

Task No.: IQM-20		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones			▲	⇧					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		100	200					300
	Field Test			50	75				125
	Evaluation								
	Promulgation								
Totals			100	250	75				425

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

oxygen bonds. A research capability to measure aldehydes and other oxygenates from mobile sources is needed in the first quarter of calendar year 1972 and a capability to routinely measure these pollutants by June 1974. This class of pollutants, like reactive hydrocarbons, requires first a definition of the composition of gaseous pollutants emitted from the automobile to enable the definition of which oxygenated species must be measured. Once the species have been identified, programs to develop methods for research analysis and eventually instruments for routine measurement can proceed.

TASK REQUIRED: Develop laboratory analytical methods for determining oxygenates from auto exhaust to provide data leading to potential standards for oxygenates (IQM-22).

TASK REQUIRED: Develop an instrumental routine method for measuring of oxygenates which could be used to make certification and inspection tests in support of a standard for oxygenates (IQM-23).

Task Title: Develop the Instrumental Capability for Routine Measurement of the Reactive Components of Auto Exhaust Consistent with the Definition of Reactivity

Task No.: IQM-21		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones					▲ ⇧	⬆			
		Funding Required ($1000's)							
Activities	Research								
	Development			75	100	200			375
	Field Test				50	50			100
	Evaluation						100		100
	Promulgation						15		15
Totals				75	150	250	115		590

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop Laboratory Analytical Methods for Determining Oxygenates from Auto Exhaust to Provide Data Leading to Potential Standards for Oxygenates

Task No.: IQM-22		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones			▲	⇧					
		Funding Required ($1000's)							
Activities	Research								
	Development		100						100
	Field Test			50					50
	Evaluation								
	Promulgation								
Totals			100	50					150

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop an Instrumental Routine Method for Measuring of Oxygenates Which Could be Used to Make Certification and Inspection Tests in Support of a Standard for Oxygenates

Task No.: IQM-23		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones					⇧ ▲	⬆			
		Funding Required ($1000's)							
Activities	Research								
	Development		50	100					150
	Field Test				75				75
	Evaluation					100			100
	Promulgation					10			10
Totals			50	100	75	110			335

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Odors are a particularly obnoxious emission from the diesel and the gas turbine. The Federal Mobile Source Program has as a goal the issuance of standards on odors from these two moving sources by mid-1975. Research techniques for quantitatively determining odor must be available for laboratory use by March 1973 to permit the obtainment of information required for setting odor standards and routine instrumental techniques for monitoring odor should be available by June of 1974 to support certification of vehicles with respect to the odor standards.

Obtaining a capability to measure odors quantitatively either from the laboratory or routinely requires that we first characterize the chemical constituents responsible for odors from the diesel and from the gas turbine.

Task Required: Chemically characterize the constituents responsible for odors from diesels and gas turbines to define chemical constituents which can be selected as the basis for a quantitative measure of odorant. (IQM-24)

TASK REQUIRED: Develop analytical techniques for the measurement of odors from moving sources (IQM-25).

Task Title: Chemically Characterize the Constituents Responsible for Odors from Diesels and Gas Turbines to Define Chemical Constituents Which Can be Selected as the Basis for a Quantitative Measure of Odor

Task No.: IQM-24		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones									1972 to 1977
		Funding Required ($1000's)							
Activities	Research		100	100	100				300
	Development								
	Field Test								
	Evaluation								
	Promulgation								
Totals			100	100	100				300

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop Analytical Techniques for the Measurement of Odors from Moving Sources

Task No.: IQM-25		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				▲	⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		100	75					175
	Field Test			100					100
	Evaluation								
	Promulgation								
Totals			100	175					275

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

TASK REQUIRED: Develop routine instrumental techniques for the measurement of odors from moving sources (IQM-26).

3.3.2.3. Particulate Pollutants

The specifics of a particulate standard for automobile exhaust emissions or for that matter whether a particulate standard ever will be issued is not known at this time. The Mobile Source Program planning assumption is that if a fine particulate standard is needed, it will be promulgated for 1977 model year vehicles. Techniques are currently available for the research determination of both total particulate and fine particulate from automobile emissions using the methods similar to those described under particulates in the stationary source measurement area. Some of these techniques must be more carefully evaluated to determine their suitability for making measurements from automobile exhaust.

TASK REQUIRED: Evaluate the available methods for the research determination of both total particulate mass loading and the quantity of fine particulates from mobile source vehicular exhaust (IQM-27).

A routine capability to measure particulates should be made available by January 1974. Presently, no routine techniques exist either for total particulate loading or for routine measurement of fine particulates.

Task Title: Develop Routine Instrumental Techniques for the Measurement of Odors from Moving Sources

Task No.: IQM-26		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones					⇧	▲ ⬆			1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			175	200				375
	Field Test				50	100			150
	Evaluation								
	Promulgation								
Totals				175	250	100			525

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Evaluate the Available Methods for the Research Determination of Both Total Particulate Mass Loading and the Quantity of Fine Particulates from Mobile Source Vehicular Exhaust

Task No.: IQM-27		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones			⇧	⬆					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test		75	100					175
	Evaluation								
	Promulgation								
Totals			75	100					175

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Before developing instrumental capabilities for these measurements, the particulate emissions from the automobile must be characterized to determine the size distribution and particulate composition.

Task Required: Characterize the particulate emissions from motor vehicle exhaust in support of potential standards for total and fine particulate mass loading as well as to provide information for design of routine instrumental monitors for these vehicular exhaust pollutants (IQM-28).

TASK REQUIRED: Develop a routine instrumental capability to measure total particulate mass loading and the quantity of fine particulates in anticipation of a possible particulate mass loading standard (IQM-29).

One of the objectionable particulate emission characteristics from motor vehicle exhausts is smoke. Emission of smoke is especially severe from the exhaust from diesel engines and from some gas turbines. Smoke meters for determining the smoke level from diesel exhaust based on the USPH smoke meter are available. Other smoke meters are also commercially available for this measurement. An evaluation of the commercial available smoke meters is required to determine acceptable instruments for use in certification and inspection programs on smoke emissions from motor vehicles.

Task Title: **Characterize the Particulate Emissions from Motor Vehicle Exhaust in Support of Potential Standards for Total and Fine Particulate Mass Loading as Well as to Provide Information for Design of Routine Instrumental Monitors for These Vehicular Exhaust Pollutants**

Task No.: IQM-28		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones									1972 to 1977
		Funding Required ($1000's)							
Activities	Research			100	100	100			300
	Development								
	Field Test								
	Evaluation								
	Promulgation								
Totals				100	100	100			300

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: **Develop a Routine Instrumental Capability to Measure Total Particulate Mass Loading and the Quantity of Fine Particulates in Anticipation of a Possible Particulate Mass Loading Standard**

Task No.: IQM-29		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧	▲⬆				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		100	100					200
	Field Test			50					50
	Evaluation				75				75
	Promulgation				10				10
Totals			100	150	85				335

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

TASK REQUIRED: Complete the evaluation of smoke meters for both diesel and gas turbine exhausts to determine their acceptability for routine use in measuring smoke from motor vehicle exhaust (IQM-30).

3.3.3 Aircraft Emission Measurements

The initial aircraft standards were to be proposed by October 27. 1971. The exhaust emissions from piston aircraft are expected to be similar enough to those encountered with motor vehicle IC engines to enable the use of the same sampling procedures with minor modifications. The jet engine will require development of sampling procedures both for gaseous and particulate pollutants.

TASK REQUIRED: Develop and evaluate sampling procedures for jet engine exhaust gaseous pollutants (IQM-31).

TASK REQUIRED: Develop and evaluate sampling procedures to obtain representative emissions for jet engine particulate pollutants (IQM-32).*

Once acceptable sampling procedures have been developed, it is expected that pollutant sensors developed for motor vehicle emission measurements will be satisfactory for measuring aircraft emissions.

Task Title: Complete the Evaluation of Smoke Meters for Both Diesel and Gas Turbine Exhausts to Determine Their Acceptability for Routine Use in Measuring Smoke from Motor Vheicle Exhaust

Task No.: IQM-30

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones			⇧	⬆					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development								
	Field Test		50						50
	Evaluation			75					75
	Promulgation			10					10
Totals			50	85					135

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop and Evaluate Sampling Procedures for Jet Engine Exhaust Gaseous Pollutants

Task No.: IQM-31

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⇧					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		100	100					200
	Field Test			75					75
	Evaluation								
	Promulgation								
Totals			100	175					275

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

3.3.4 Measurement Procedures to Support EPA Programs to Register and Regulate Fuels and Fuel Additives

Analytical techniques and instrumentation are required to determine both the nature and amount of emissions resulting from the use of fuels and fuel additives. Official techniques will be required for analysis of those additives which are regulated to facilitate determination of compliance with the regulations. These emissions are expected to consist of low concentrations of materials which were considered as air pollutants or trace metals in the ambient air quality monitoring and stationary source emission measurement areas. The measurement techniques developed in these two areas and techniques supplied by manufacturers during registration will provide the foundation for measurements required in support of the fuels and fuel additive registration program. An evaluation of these techniques is required to determine if they are acceptable for measurement of the nature and amount of emissions resulting from the use of fuels and fuel additives, and the development of detailed procedures for conducting the measurements. Present plans call for registration of motor vehicle gasoline, fuels and fuel additives, aviation fuels and fuel additives, diesel fuels and fuel additives, heating fuels and fuel additives, LPG fuels and fuel additives and lubricants and their additives.

TASK REQUIRED: Evaluate measurement techniques developed for air pollutants and trace metals to determine if they are

Task Title: Develop and Evaluate Sampling Procedures to Obtain Representative Emissions for Jet Engine Particulate Pollutants									
Task No.: IQM-32		Fiscal Year							
		Pre 72	72	73*	74	75	76	77	Totals
Milestones					⇑				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development			200					200
	Field Test				75				75
	Evaluation								
	Promulgation								
Totals				200	75				275

▲ Date Capability Initially Required ⇑ Evaluated Method available
⇧ Interim Method Available

acceptable for measurements to support the fuels and fuel additives registration program; and promulgate official measurement techniques for analysis in fuel of additives to be regulated. (IQM-33).

TASK REQUIRED: Develop the procedures required to determine the nature of and the amount of emissions resulting from the use of fuels and fuel additives to support the fuels and fuel additive registration program. (IQM-34)

Task Title: Evaluate Measurement Techniques Developed for Air Pollutants and Trace Metals to Determine if They are Acceptable for Measurements to Support the Fuels and Fuel Additives Registration Program and Promulgate Official Measurement Techniques for Analysis in Fuel of Additives to be Regulated

Task No.: IQM-33

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones					⇧				1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		300	250					550
	Field Test			100	100				200
	Evaluation			70	100	50			220
	Promulgation			10	10	10			30
Totals			300	430	210	60			1000

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

Task Title: Develop the Procedures Required to Determine the Nature of and the Amount of Emissions Resulting from the Use of Fuels and Fuel Additives to Support the Fuels and Fuel Additive Registration Program

Task No.: IQM-34

		Fiscal Year							
		Pre 72	72	73	74	75	76	77	Totals
Milestones				⬆→					1972 to 1977
		Funding Required ($1000's)							
Activities	Research								
	Development		120	100	200	200	200	200	1020
	Field Test			75	150	150	150	150	675
	Evaluation								
	Promulgation								
Totals			120	175	350	350	350	350	1695

⬆ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

4. TECHNIQUES TO SUPPORT EPA PROGRAMS TO MAINTAIN ADEQUATE MEASUREMENT CAPABILITIES

This section of the report describes the tasks required to develop the procedures and techniques required to support a continuing EPA program to maintain an adequate measurement capability in support of the Nation's air pollution control program. These tasks support a program to determine the equivalency of new measurement techniques and support the quality control program.

4.1 Equivalency Testing

The Environmental Protection Agency has through promulgations defined both the type of measurement and in some cases the number of measurements required to comply with various air pollution control standards. An extension of these measurement requirements to the additional pollutants and sources for which standards are planned will result in a considerable market for air pollution measurement equipment. While the market for ambient air quality monitors is perhaps not large enough to support research and development expenditures by private industry, the market for stationary source emission measurement and parts of the market for the moving source emission measurement should lead to considerable industrial R&D expenditures.* The instrumentation industry, based on contacts they have made with EPA, appears very interested in serving this market. New and improved measurement techniques can be expected as the instrumentation industry competes for the market. EPA intends to encourage this interest on the part of the instrumentation industry, as it represents the potential for improved and perhaps lower cost measurement techniques without the need for continued EPA funding for development of improved instrumentation. New instrumentation does, however, pose a problem for EPA.

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*See Appendix B

In order to insure the timely availability of measurement techniques for the air pollution control program, EPA will have to conduct field test and user evaluations of currently available measurement instrumentation prior to the effective date of standards. The necessary tasks to conduct these tests and evaluations were discussed in Section 2. It is not likely that the instrumentation industry will make significant private commitments to develop new instruments until the market for these instruments exists, and the market will follow the issuance of the standards. In order to get these new instruments into widespread use in the air pollution control program they will have to be certified by EPA as equivalent to the measurement techniques originally proposed at the time the standards were promulgated. Certification of new instruments by recycling them through the EPA field testing,user evaluation, and promulgation activities would be a very costly and never ending process. An alternate procedure for certifying these instruments as acceptable measurement techniques must be developed. Procedures which can be considered for this purpose include: (1) requiring the manufacturer to conduct the field test and user evaluations of the instrument according to EPA specifications; and (2) developing a set of criteria for instrument performance similar to those used in "military specifications".

EPA has initiated this program in a contract to the State of California to provide "Performance Evaluation Procedures for Continuous Atmospheric Analysers". The information generated will allow the preparation of a manual of methods for continuous air analysers related to performance rather than specific commercial instruments.

This plan provides for the continued development and evaluation of the procedures required to conduct equivalency determinations. The plan does not provide the funding or manpower required to run the equivalency determination program.

TASK REQUIRED: Develop and evaluate procedures for determining the equivalency of new measurement techniques. (MP-1)

4.2 Quality Control

Two of the elements included in the portion of the quality control program within the scope of this plan are: (1) standard gas mixtures for routinely calibrating measurement methods in general use; and (2) the periodic evaluation of the performance level of the user of these methods.

The capability to routinely calibrate measurement methods which are in general use requires the availability of calibrated gas mixtures. It is difficult to obtain a gas mixture of known composition suitable for use in the air pollution control program because of the low level and at times reactivity of the air pollutant being measured. This is particularly true in the ambient air quality level monitoring program where pollutant concentrations are often in the ten parts per billion

Task Title: Develop and Evaluate Procedures for Determining the Equivalency of New Measurement Techniques

Task No.: MP-1

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones				•	⬆				
		Funding Required ($1000's)							1972 to 1977
Activities	Research								
	Development		50	150					200
	Field Test				75				75
	Evaluation								
	Promulgation				15				15
Totals			50	150	90				290

▲ Date Capability Initially Required ⬆ Evaluated Method Available
⇧ Interim Method Available

range. Recognizing this problem, EPA has initiated a program to develop acceptable standard gases for use in measurement techniques calibration. An EPA in-house program has already led to a practical approach for obtaining the low levels of SO_2 needed to calibrate ambient quality level measurement methods for this air pollutant. This approach based on the permeation of liquid sulfur dioxide through a permeable membrane has been available from the National Bureau of Standards since October 1970 as a Standard Reference Material for SO_2. The feasibility of using NO_2 permeation tubes and the development and certification of a stable reproducible ozone source is underway at NBS. The development of similar Standard materials to routinely calibrate the measurement methods for all pollutants subject to standards must be pursued. The task to accomplish this end must include a significant research activity to demonstrate feasible approaches.

TASK REQUIRED: Develop and evaluate standard materials to enable the routine calibration of measurement methods in general use. (MP-2)

The evaluation of user performance level requires the establishment of test procedures and the development of test samples. Unknown test samples, representative of the pollutant atmosphere to be measured, would be periodically sent to participating laboratories and operators for analysis at their location. The results of the analysis would be

Task Title: Develop and Evaluate Standard Materials to Enable the Routine Calibration of Measurement Methods in General Use

Task No.: MP-2

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	
Milestones				▲→					1972 to 1977
		Funding Required ($1000's)							
Activities	Research		75	100	100				275
	Development		100	200	200	150	100	100	850
	Field Test			50	50	50	50	25	225
	Evaluation			50	50	50	50	25	225
	Promulgation			5	5	5	5	5	25
Totals			175	405	405	255	205	155	1600

▲ Date Capability Initially Required ⇧ Evaluated Method Available
⇧ Interim Method Available

reviewed by EPA to determine the competance of individual users to make valid measurements. This evaluation procedure is similar to that employed by some state agencies to certify laboratories for making water quality level measurements. It is expected that this program will be the cornerstone for a nation-wide air pollution measurement certification program. This plan provides for development and evaluation of the necessary test procedures and test samples required to establish the user performance level evaluation program. The plan does not provide for the funding or manpower to conduct the user evaluation program.

TASK REQUIRED: Develop and evaluate the procedures and test samples for a program to periodically evaluate the performance level of users of measurement techniques. (MP-3)

Task Title: Develop and Evaluate the Procedures and Test Samples for a Program to Periodically Evaluate the Performance Level of Users of Measurement Techniques

Task No.: MP-3

		Fiscal Year							Totals
		Pre 72	72	73	74	75	76	77	1972 to 1977
Milestones				⇧	⬆				
		Funding Required ($1000's)							
Activities	Research								
	Development		75	150					225
	Field Test			50					50
	Evaluation				100				100
	Promulgation				15				15
Totals			75	200	115				390

▲ Date Capability Initially Required
⇧ Interim Method Available
⬆ Evaluated Method Available

5. RESOURCES REQUIRED

This section of the report covers the resources required to implement the RDT&E plan.

The task statements presented in Part 3 of the report give the first glimpse into the magnitude of the funding that is required to carry out the measurement technique development program. In this section, the funding data from these task sheets will be consolidated and summarized by application areas, activities, pollutants and the fiscal year in which the funding is required.

In the scope of the plan Part 1, Section 3, we have indicated that the funding level shown on the task sheets is only sufficient to carry out a single approach to achieve the measurement capability required, and is not sufficient to repeat the development, field test, user evaluation and promulgation activities if the measurement method is found to be unacceptable. In this section the necessary funding to provide for replacement or improvements of measurement methods as required to assure the availability of adequate measurement techniques will be considered.

So far the plan has only considered the measurement needs that are either currently required or which can be projected to be required based on current legislation. The funding required to improve measurement techniques in anticipation of the needs posed by future legislation will be considered.

The resources required to implement the plan include EPA manpower in addition to funding availability. The probable manpower requirements will be discussed.

5.1 Consolidation of Funding Requirements on TASK Statements

The funding requirement shown on the Task Statements totals over $50 Million over the period fiscal year 1972-1977, with a peak funding requirement of $17 Million in fiscal year 1973.

5.1.1 Funding by Application Areas

A breakout of the funding by application areas is shown in Table 3.1 and is summarized below for the three major application areas.

Application Area	Funding Requirement FY 1972-1977 Millions of Dollars
• Support of EPA Research & Investigation Programs	7.04
• Identification & Quantification of Pollutants	41.00
• Support of EPA Maintenance Programs	2.29
	50.33

5.1.2 Funding by Activities

The funding requirement by activities and application areas is given in Table 3.2. A summary of the funding by activities for the period covered by this plan is given below.

Activity	Funding Requirement FY 1972-1977 Millions of Dollars
• Research	3.725
• Development	22.165
• Field Test	12.650
• Evaluation	10.470
• Promulgation	1.365
	50.375

TABLE 3.1

SUMMARY OF FUNDING REQUIRED BY APPLICATION AREAS*

	Fiscal Year							Totals FY-1972 to FY-1977
	1971	1972	1973	1974	1975	1976	1977	
Support of EPA Research & Investigation Programs								
• Health & Welfare Effects		0.225	0.750	0.575	0.31	0.06	--	1.92
• Remote Sensing Programs		0.575	1.125	1.05	0.69	0.24	--	3.68
• Meteorological Measurements		0.56	0.53	0.20	0.15	--	--	1.44
		1.36	2.405	1.825	1.15	0.30	--	7.04
Identification & Quantification of Pollutants								
• Ambient Air Quality Monitoring	1.86	1.71	4.70	4.62	2.60	0.62	0.01	14.26
• Stationary Source Emission Measurements	1.90	2.44	4.60	3.86	1.74	0.82	0.12	13.58
• Moving Source Emission Measurement	1.28(a)	2.16	4.33	3.26	2.15	0.83	0.43	13.16
	5.04(b)	6.31	13.63	11.74	6.49	2.27	0.56	41.00
Support of EPA Programs to Maintain Adequate Measurement Capabilities								
• Equivalency Determination Program		0.05	0.15	0.09	--	--	--	0.29
• Quality Control Program		0.25	0.60	0.52	0.26	0.21	0.16	2.00
		0.30	0.75	0.61	0.26	0.21	0.16	2.29
TOTALS	5.04	7.97	16.785	14.175	7.90	2.78	0.72	50.330

*Millions of Dollars

(a) Includes $300,000 of Supplemental Funds for Fuel Additive Registration - Emissions Research

(b) Includes $674,970 of FY-1971 Carry-Over Funds

TABLE 3.2

SUMMARY OF FUNDING REQUIRED FY 1972-77 BY APPLICATION AREAS AND ACTIVITIES*

	Support of EPA Programs on Research and Investigations			Identification and Quantification of Pollutants			Support of EPA Maintenance Programs		
Activity	Health & Welfare	Remote Sensing	Meteorology	Ambient Air Quality	Stationary Source	Moving Source	Equivalency Determination	Quality Control	Totals
Research	525	675	--	1125	525	600	--	275	3725
Development	825	1800	1145	6580	3970	6570	200	1075	22165
Field Test	350	700	300	2875	4575	3500	75	275	12650
Evaluation	200	450	--	3620	4025	1850	--	325	10470
Promulgation	20	55	--	460	535	240	15	40	1365
TOTALS	1920	3680	1445	14660	13630	12760	290	1990	
	7045			41050			2280		50375

* Thousands of Dollars

5.1.3 Funding by Pollutant

The matrix of capability needs, Part 2, Section 2, has been used to assign the funding to specific pollutants. If a task involves more than one pollutant, the funding assignment reflects a pro-rata share of the task cost to each pollutant. The funding by pollutant and application area year is given in Table 3.3. The funding requirement by pollutant is summarized below.

Pollutant	Funding Required Fiscal Years 1972-1977 Millions of Dollars
• Sulfur Oxides	3.54
• Oxides of Nitrogen	3.72
• Particulates	10.84
• Hazardous Pollutants	4.70
• Carbon Monoxide	1.50
• Hydrocarbons	6.07
• Odors	4.10
• Halogen	1.86
• Oxidants	1.23
• Other Pollutants	3.575

5.2 Funding for Replacement and/or Improvement of Measurement Methods

Once measurement techniques are developed and in use for one to two years, some techniques will be unacceptable in routine practice, others will need major or minor improvements. It is assumed that 50% of all techniques will be completely acceptable, 20% will require minor and 20% major improvements and 10% replacements. The cost of minor improvements is assumed to be 30% of development of a new instrument, of major improvements 60% of new instrumental development. The total

TABLE 3.3

SUMMARY OF FUNDING REQUIRED FY 1972-77 BY APPLICATION AREA AND POLLUTANT*

Pollutants	Support of EPA Programs on Research and Investigations			Identification and Quantification of Pollutants			Support of EPA Maintenance Programs		Totals
	Health & Welfare	Remote Sensing	Meteorology	Ambient Air Quality	Stationary Source	Moving Source	Equivalency Determination	Quality Control	
Sulfur Oxides	105	840	--	1045	1230	--	--	325	3545
Oxides of Nitrogen	105	755	--	1820	590	135	--	320	3725
Particulates									
• Mass. Loading	--	340	--	1045	3665	1545	--	--	6595
• Visible Emissions	--	625	--	210	975	135	--	--	1945
• Other Properties	--	--	--	985	1105	210	--	--	2300
Carbon Monoxide	105	--	--	510	310	260	--	315	1500
Hydrocarbons	--	245	--	2190	715	2605	--	315	6070
Halogens	--	430	--	660	775	--	--	--	1865
Oxidants	105	245	--	555	--	--	--	325	1230
Other Pollutants	105	--	--	1305	1005	300	--	--	2715
Odors	--	--	--	1735	1260	1100	--	--	4095
Not Pollutant Specific	535	200	1445	--	460	5860**	290	390	9180
Hazardous Pollutants	--	--	--	2605	1490	610	--	--	4705
Aeroallergens	860	--	--	--	--	--	--	--	860
TOTALS	1920	3680	1445	14665	13580	12760	290	1990	
	7045			41005			2280		50330

* Thousands of Dollars

**Primarily for Development of Sampling Procedures factor of 0.28 is multiplied times the average yearly cost of measurement technique development, and this amount is added to the costs for the second fiscal year following, e.g., 28% of the base funding for FY 1972 is added to the FY 1974 funding requirements. Since there is no way to ascertain which specific tasks will require this additional effort, it is not possible to allocate the funds to specific items.

5.3 Funding for Future Requirements

The funding requirements defined so far only provide for measurement techniques to satisfy the measurement needs imposed by current legislation. The nation's air pollution control program is however still in the formative stages and new legislation can be expected during the period covered by this plan. It is anticipated that future legislation will require the availability of improved instrumentation, e.g., higher sensitivity and better specificity. Obtaining this degree of improvement in measurement capabilities will require substantial advances in the state of the art and accomplishing these advances will require long lead time. A research and development program to provide for advancement of the state of the art of measurement technology is required. This program would be done "in-house" and through EPA sponsorship of research grants to the academic community. It is difficult to set an amount of funding for this activity although a figure of approximately 10% of the measurement development program base funding level or some 5 million dollars over the time period of this plan seems reasonable. Manpower limitations will require that this funding be concentrated in the last three years of the plan period.

5.4 Funding Summary

The total funding required in fiscal years 1972 to 1977 to implement the measurement technique development plan is 69 million dollars. In fiscal years 1973 to 1975 the funding required is two or three times that currently budgeted for FY 1972. Table 3.4 summarizes the funding required by fiscal year.

TABLE 3.4

SUMMARY OF THE TOTAL FUNDING REQUIRED FOR MEASUREMENT TECHNIQUE DEVELOPMENT*

	Fiscal Year							Totals FY-1972 to FY-1977
	1971	1972	1973	1974	1975	1976	1977	
(A) Base Funding Level	5.04	7.97	16.785	14.075	7.90	2.78	0.72	50.335
(From Individual Task Statements, see Table 3.1)								
(B) Replacement & Improvements of Developed Methods	--	--	1.41	2.19	4.68	3.94	2.20	14.42
(c) R&D to Prepare for Future Requirements	--	--	--	--	1.00	2.00	2.00	5.00
TOTALS	5.04	7.97	18.195	16.265	13.58	8.72	4.92	69.195

* Millions of dollars

5.5 Manpower Required

The implementation of the measurement technique development plan will require EPA manpower in addition to the funding requirements previously discussed. This manpower will be needed to conduct the in-house programs, to monitor and administer the contract program and for general program supervision.

At the peak funding period of FY-1973, some 18 million dollars is required for the measurement development program. It is expected that 15 million dollars will be in contract programs requiring 30 people for contract monitoring and administration. About 65 people will be required for the in-house program and 20 people for general program supervision during this period, for a total manpower requirement of 115 people.

By FY-1977 it is anticipated that approximately 50% of the measurement development program will be "in-house" with emphasis on programs to advance the state-of-the-art. The 2.5 million dollars to be spent in the in-house programs will require some 80 people directly involved in laboratory programs. Contract monitoring and administration should require an additional 6 people, on the assumption that one person can monitor about 500 thousand dollars of contract research. At the relatively small size of the contracts let in the measurement development program this amounts to 5-6 contracts per contract monitor. General program supervision will require an additional 19 people, for a total manpower requirement of 105.

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APPENDIX A

MEASUREMENT TECHNIQUE DEVELOPMENT EFFORTS OUTSIDE EPA

A.1 Efforts in Other Federal Agencies

A.2 Efforts in State and Local Agencies

A.3 Efforts Within Organizations

A.4 Industrial Efforts

APPENDIX A

MEASUREMENT TECHNIQUE DEVELOPMENT EFFORTS OUTSIDE EPA

This plan defines the EPA measurement technique development effort. In developing the plan, consideration was given to measurement development efforts in several other sectors: Federal agencies, state and local governmental agencies, private organizations, and industry.

A.1 Efforts in Other Federal Agencies

During the course of this program visits were made to the following Federal facilities to gather information on measurement technique development. (EPA personnel have contacted additional facilities whose programs and activities have been reflected in this plan, but these have not been enumerated.)

(1) NASA Laboratory for Electronics Research, Cambridge, Mass.

(2) Office of Aerospace Research (U.S. Air Force), Arlington, Va.

(3) Army Research Office, Arlington, Va.

(4) Defense Development & Engineering Laboratory, Edgewood Arsenal, Md.

(5) Air Force Cambridge Research Laboratory, Mass.

(6) Land Warfare Laboratory, Aberdeen Proving Ground, Md.

(7) National Center for Atmospheric Research, Boulder, Colorado.

(8) Instrumentation Laboratory (MIT), Cambridge, Mass.

From these visits efforts in other Federal agencies were observed that involve pertinent measurement techniques needed for support of EPA research and investigation studies. EPA is maintaining close liaison with these governmental facilities. A summary of the more pertinent observations follows.

Defense Development & Engineering Laboratory
Edgewood Arsenal, Md.

The IR applications group is active in all aspects of LOPAIR, laser and remote detection techniques. This group has been active in this field since the mid-50's and now spends 1 1/2-2 million dollars per year on these programs. Currently developed capability includes active and passive LOPAIR, isotopic CO_2 laser for active LOPAIR, laser raman shift for LOPAIR, and laser raman remote measurement. Contractors include Bendix, G. E. and Block Engineering. Similar work is also underway at NASA Langley and at the Naval Research Office.

The Alarms group has a very impressive "package-engineering" capability, particularly with their E-41 and M-8 battery operated colorimetric field analysers. These devices use detection principles similar to many commercially available AP instruments. Air pollution instruments with similar "package-engineering", dust-proofness, temperature control, ruggedness and modular construction would be significant advances for field use.

Defense Research Department
Edgewood (MD.) Arsenal

The Detection Research Laboratory works on personal detectors, enzyme-based detectors, miniature mass spectrometers and pico-gram, quantity analysis. Areas of expertise include the detect of pesticides and chlorine containing materials.

The work on solid state detectors is concerned with the development of simple detector devices, some based on the fluorescence principle. Although most of the relevant work in solid state detection is classified, indications are that some potential air pollutants can be measured using currently available detectors.

Land Warfare Laboratory
Aberdeen Proving Ground, Md.

This laboratory has an impressive capability in the detection of condensation nuclei. Condensation nuclei (CN) are extremely small particles, 0.001 to 1 micron diameter, which resulting from combustion and industrial fumes and mists. Their XM-3 unit is an airborn detector capable of producing CN contours over incinerators, stacks, open burning areas (traces shown during the contractors visit were very impressive). The E-63 is man-pack version of the CN detector. Work is also underway on portable mass-spectroscopy and plasma gas chromatographic detection techniques.

NASA
Houston, Texas

The Earth Resources Group is evaluating multi-spectral scanners for the airborn measurement of the extent and effects of air pollution.

NCAR
Boulder, Colorado

NCAR is an NSF-funded research center specializing in atmospheric science. Most of its staff is concerned with the upper atmosphere. However, some of its efforts are applied to pollution-type problems, with a group concerned with atmospheric chemistry. This group is heavily involved in methods development and evaluation and is particularly concerned with the measurement of very low levels of pollutants. Another group is working on photochemistry, including chemiluminescence and the analysis of peroxyaclnitrate.

A.2 Efforts in State & Local Agencies

During the development of the plan the contractor made contact with the following state and local agencies.

(1) New York City Air Resources Agency

(2) Los Angeles County Air Pollution Control District

(3) New Jersey Air Pollution Control Department

(4) Bay Area Air Pollution Control Administration

(5) Allegheny County Air Pollution Control Administration

(6) California Air Resources Board

(7) New York State Air Pollution Monitoring Network

(8) Massachusetts Division of Environmental Health

(9) Boston Air Pollution Control Commission

Most of these agencies are engaged in some programs involving measurement technique development. In most cases the programs are limited to the evaluation of commerically available instruments or the development of analytical methods required to obtain data on pollutants which are of concern in the local air quality region but which have not yet been covered by NAQS. The need for this activity at the state and local level should diminish as the EPA measurement technique development effort reaches maturity.

Some agencies have been involved in major measurement techniques development programs, e.g. the New Jersey auto exhaust inspection program, funded in part by an EPA grant and the California Air Resources Board's "Project Clean Air".

In the case of Project Clean Air, efforts are being made to avoid duplication of CARB and EPA activities. These efforts are mainly in the form of close verbal and written communications between the board members and personnel of EPA. CARB has been informed that EPA considers the development of measurement methods and instrumentation for Air Pollution Control a Federal responsibility and, therefore, that it is unnecessary to fund such efforts through Project Clean Air. Further, the relatively short term of "Project Clean Air" will allow little more than a limited evaluation of available instruments.

A.3 Efforts Within Organizations

The contractor held discussions with the following private organizations in an effort to determine development work in the private sector.

(1) National Council of the Paper Industry for Air and Stream Improvement, Inc.

(2) American Iron and Steel Institute

(3) American Society for Testing and Materials (ASTM)

The only major effort underway is Project Threshhold, an ASTM sponsored endeavor. This major, concerted effort to obtain knowledge about precision and accuracy is being undertaken by ASTM to produce authoritative standard methods for measuring more than thirty important pollutants. Approximately thirty-five standard methods will be evaluated over a three-year period by five contracting cooperators, supplemented by qualified volunteer participants. The scientific planning of the work includes statistical gathering and analysis of the data in accordance with ASTM criteria. The cooperative tests will be conducted on real, rather than synthetic, samples under conditions of use. Personnel and equipment from each cooperating laboratory will be assembled at a field location suitable for each pollutant, to take their samples simultaneously and to perform the analysis separately either on-site or later, in their own laboratories. The data and related findings will be reported as available to Committee D-22, providing the basis for recommending the addition of statements on accuracy and precision pertinent to each test method. Acceptance of these recommendations will be confirmed by a letter-ballot of the entire committee and of the Society. Standard Reference Materials will be prepared by the National Bureau of Standards so that the accuracy of the methods can be proven. These materials also make it possible to validate future measurements and to calibrate measuring instruments. A Research Associate, employed by ASTM, will augment the NBS research staff.

EPA acknowledges the activities of Project Threshhold. Unfortunately, Project Threshhold activities do not involve testing of manual and instrumental methods proposed by EPA in Regulations announced in the Federal Register. The validation of these methods as alternate methods for measurement(s) would be useful contribution to the Nation's air pollution control program. EPA is maintaining contact with this project through its liaison member to committee D-22 of the ASTM.

A.4 Industrial Efforts

The contractor made visits to several industrial firms engaged in the development and manufacture of air pollution measurement instrumentation during the course of this program. These visits were made primarily to determine the market for air pollution instrumentation, which is the subject of another report issued under this contract. In addition some three score additional manufacturers contacted the contractor to discuss the market and their development efforts.

While a considerable number of interesting measurement techniques are being worked on in the industrial sector, there were no surprise projects. Industry has developed some new measurement techniques but most of the projects have received some EPA financial support in either the prototype development or the evaluation stage. From this level of industrial activity and the conclusion of the market study that a substantial market opportunity exists for source emission measurements, it is likely that the industrial sector will be the prime source of new instruments for test and evaluation by EPA. This RDT&E plan accordingly assumes that little EPA effort and resources will be required to develop source emission instruments, although considerable testing and evaluation of the instruments by EPA will be required.

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APPENDIX B

A STUDY OF MARKETS FOR AIR POLLUTION MEASUREMENT INSTRUMENTATION 1971-1980

B.1 Ambient Air Quality Level Monitoring

B.2 Stationary Source Emission Measurements

B.3 Auto Emission Measurements

B.4 Dollar Value of the Market

B.5 Time Frame for the Market

APPENDIX B

A STUDY OF MARKETS FOR AIR POLLUTION MEASUREMENT INSTRUMENTATION 1971-1980

This report presents an analysis of the domestic market for air pollution instrumentation for the period 1971-1980.*

The market for air pollution instrumentation during the decade of the 70's has been determined as part of a project being conducted by Esso Research and Engineering Company for the Office of Air Programs of the Environmental Protection Agency. This project has as its primary objective the delineation of a federal research and development plan for air pollution measurement instrumentation. One part of this project involved a market analysis to assess the opportunities available and thus the contribution to this R/D program that might be expected from the private sector in providing the measurement instrumentation required to assure the ability of this nation to conduct an effective air pollution control effort.

The market for three different areas requiring instruments to obtain information on the concentration level of air contaminants is discussed. These include: monitoring of the ambient air quality level, measurement of the emissions from stationary sources of air pollution, and measurement of the emissions from the automobile. The market for these areas of instrumentation is based on a review of instrumentation requirements at the federal, state, and local level and on an analysis of current legislation and air pollution control codes.

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*The work reported here was performed under Contract No. CPA 22-69-154 for the Office of Air Programs of the Environmental Protection Agency. The statements and conclusions presented are those of the author and do not necessarily reflect the views of the Environmental Protection Agency. The full report summarized here is now available as Document No. APTD-0800, through the National Technical Information Service, No. PB 204,174.

The scope of the market analysis has been limited to the sensors required to detect and measure air contaminants and special hardware required to obtain the sample. We have specifically excluded from our market estimate the quantity and value of telemetering equipment and the cost of instrument maintenance. The analysis also excludes the market for instrumentation needed for the research and development programs which will support the Nation's air pollution control program. The dollar value estimates presented in this report include, where appropriate, a device to record the pollutant concentration level.

B.1 Ambient Air Quality Level Monitoring

The market for ambient air quality level measurement equipment has been divided into two basic types of air monitors. The automatic and continuous, sample-analyzer monitors produce numerical and/or graphical information directly. The non-automatic or intermittent monitors employ collection devices and separate laboratory facilities for subsequent analysis of the sample.

In this study of the market for ambient air quality monitoring, we have considered only instrumentation required for the following air contaminants: particulates, sulfur dioxide, oxidants, carbon monoxide, hydrocarbons, oxides of nitrogen, fluorides, polynuclear organic matter, and odors.

The market for continuous air quality monitors during the decade, while impressive in terms of the total number of new instruments required, is fragmented into many different analyzers each with a relatively small market.

TABLE 1

SUMMARY: CONTINUOUS AMBIENT AIR QUALITY LEVEL MONITOR REQUIREMENTS

Analyzer	Instrumentation Market 1971-1980 (Units)		
	Initial	Replacement	Total
Sulfur Dioxide	671	750	1421
Nitric Oxide	626	510	1136
Nitrogen Dioxide	744	650	1394
Carbon Monoxide	722	660	1382
Non-Methane Hydrocarbon	950	570	1520
Oxidants (Ozone)	814	620	1434
Polynuclear Organic Matter	380	110	490
Odors	867	425	1292
Automatic Tape Soiling Index	386	--	386
Particulate	570	--	570
Fluorides	380	--	380

Non-automatic air monitors will be a significant part of the total agency requirements for ambient monitoring. These monitors have the potential to be an effective means for providing a reasonable definition of air quality over urban areas as well as background pollutant levels in less polluted portions of the country. Requirements in this area include:

TABLE 2

SUMMARY: NON-AUTOMATIC AMBIENT AIR QUALITY LEVEL MONITOR REQUIREMENTS

Collection Devices	Market 1971-1980 (Units)		
	Initial	Replacement	Total
Gas Collector Devices	16838	9578	26416
Dust Fall Collector for Settleable Particulates	6713	5643	12356
High Volume Sampler for Suspended Particulates	7233	5383	12616

B.2 Stationary Source Emission Measurements

The stationary source emission measurement market that has been estimated is based on measurements that the author anticipates will be made by industry and by the control agencies under current air quality legislation and legislative trends. The stationary source emission measurement instrumentation estimates have been based on discussions with representatives of selected industries and on an analysis that has considered: legislation, AP codes and the magnitude of the air pollution problem for a particular industry.

This market estimate for stationary source emission measurement instrumentation includes instrumentation for continuous source monitoring of the following air contaminants: particulates, sulfur dioxide, oxides of nitrogen, hydrocarbons, carbon monoxide and fluorides. Instrumentation requirements for these source emission measurements are expected to be a major fraction of the total source emission instrumentation market during the decade, although additional markets, which were not considered in this analysis, can be expected for measuring other air pollutants which are emitted from stationary sources.

Instrumentation needs in the stationary source emission measurement area include:

TABLE 3

SUMMARY: STATIONARY SOURCE EMISSION MONITORING REQUIREMENTS

Analyzer	Instrumentation Market 1971-1980 (Units)		
	Initial	Replacement	Total
Particulates	18800	5120	23920
Sulfur dioxide	3935	1075	5010
Carbon monoxide	2705	1840	4545
Hydrocarbons	4755	825	5580
Nitrogen oxides	9760	2110	11870
Fluorides	505	165	670

In addition, a market exists for 500 instruments to remotely measure the emissions from stationary sources.

B.3 Auto Emission Measurements

The potential market for auto exhaust emission measurements assumes the adoption of an annual nation-wide auto exhaust measurement program. The agency instrumentation requirements were estimated using two possible alternate inspection testing procedures. The first alternate involves an extrapolation of the state inspection lanes that would be required to inspect on a once-a-year basis each vehicle in the United States using the plans and inspection lane requirements of the State of New Jersey as a model. The second alternate involves the use of state franchised auto emission inspection facilities. Each auto emission inspection alternative investigated suggests a major instrumentation requirement.

TABLE 4

SUMMARY: AUTO EXHAUST EMISSION INSPECTION TESTING REQUIREMENTS*

Analyzer	Instrument Market 1971-1980 (Units)		
	Initial	Replacement	Total
Carbon monoxide	4240	2968	7208
Hydrocarbon	4240	2968	7208
Nitrogen oxides	4240	2544	6784
Particulates	4240	--	4240

The auto emission measurement market also includes the purchase of measuring instrumentation by the service area segment for use by service stations and auto repair facilities to adjust the auto emission control devices of those automobiles that have been found to be unacceptably high polluters during the state inspection. This market segment provides an opportunity for the development of a low cost combined hydrocarbon-carbon monoxide instrument to measure auto exhaust emissions. In the mid to late seventies a nitrogen oxides instrument may also be required for the same market.

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* The estimates presented in Table 4 are based on conducting the auto exhaust emission measurements in state inspection lanes. The estimate of the total auto emission measurement market if inspection testing is conducted in state franchised auto emission inspection facilities is given in Tables 28 and 30.

TABLE 5

SUMMARY: AUTO EXHAUST EMISSION SERVICE AREA REQUIREMENTS

Analyzer	Market 1971-1980 (Units) Initial	Replacement	Total
Hydrocarbon-carbon monoxide (combined analyzer)	176000	35200	211200

A small market also exists for industry purchases of instrumentation to conduct end-of-the-line emission quality assurance testing.

B.4 Dollar Value of the Market

The market amounts to nearly one-half billion dollars during the coming decade, some 76% of which represents initial purchases of air pollution measuring equipment. Industry will be the major purchaser of instrumentation accounting for 45% of the market. The market is heavily oriented towards stationary source emission measurement instrumentation, this area accounting for 51% of the total instrumentation market value.

TABLE 6

ESTIMATE OF AIR POLLUTION INSTRUMENTATION MARKET TOTAL VALUE 1971-1980

(Millions of Dollars)

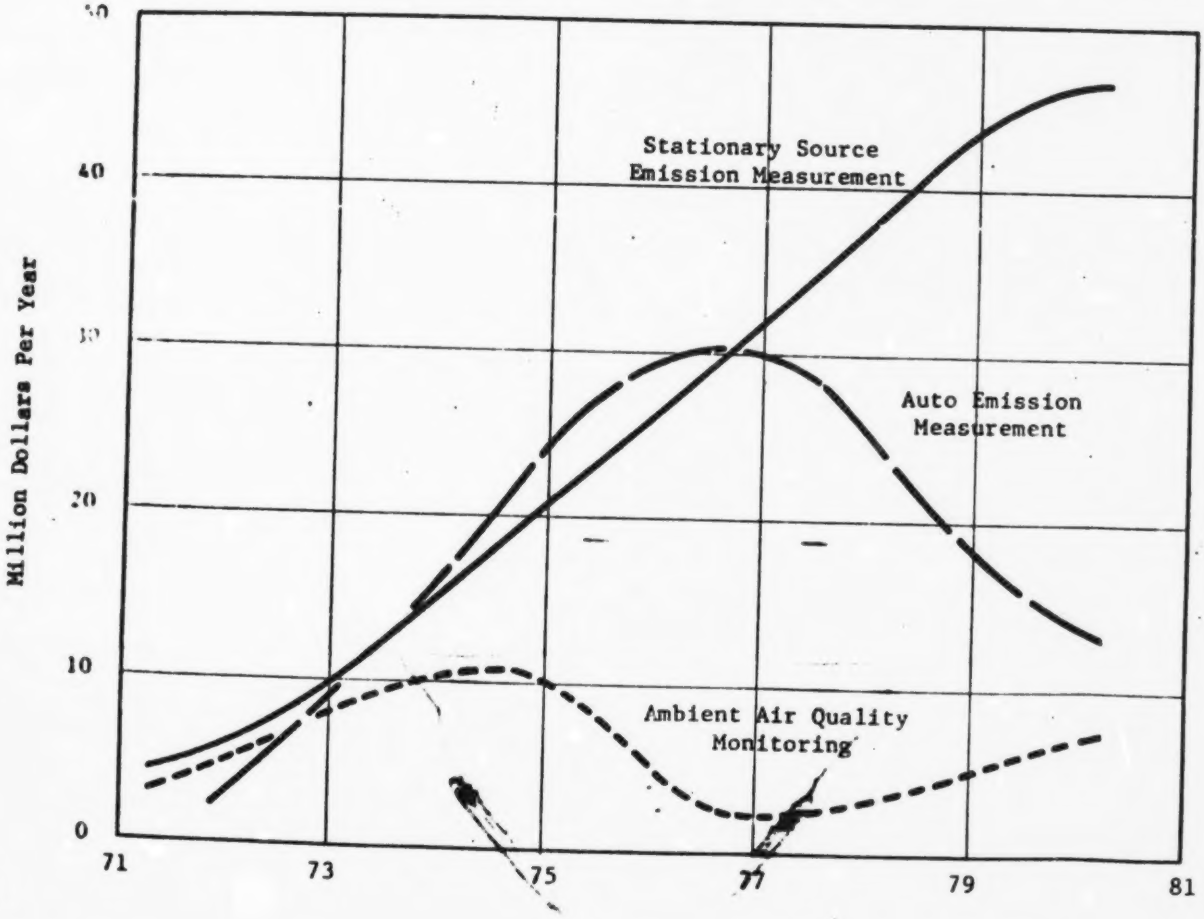
	Initial Purchase	Replacement	Totals
Ambient Level			
• Agency (CAM)	25	17	42
• Agency (Non-Automatic)	12	8	20
	37	25	62
Stationary Source Emission			
• Industrial	167	46	213
• Agency	25	5	30
	192	51	243
Auto Emissions			
• Agency	47	19	66
• Service Area	87	18	105
• Industry	3	1	4
	137	38	175
TOTALS	366	114	480

B.5 Time Frame for the Market

Timing appears to be a critical factor in the market with each of the three areas of measurement reaching maturity at different periods during the decade. The ambient air quality level monitoring market is expected to reach maturity about 1975 and the auto emission measurement instrumentation market about 1977, while the stationary source emission measurement instrumentation market will continue to grow throughout the decade.

FIGURE 1

TIME FRAME FOR THE INSTRUMENTATION MARKET



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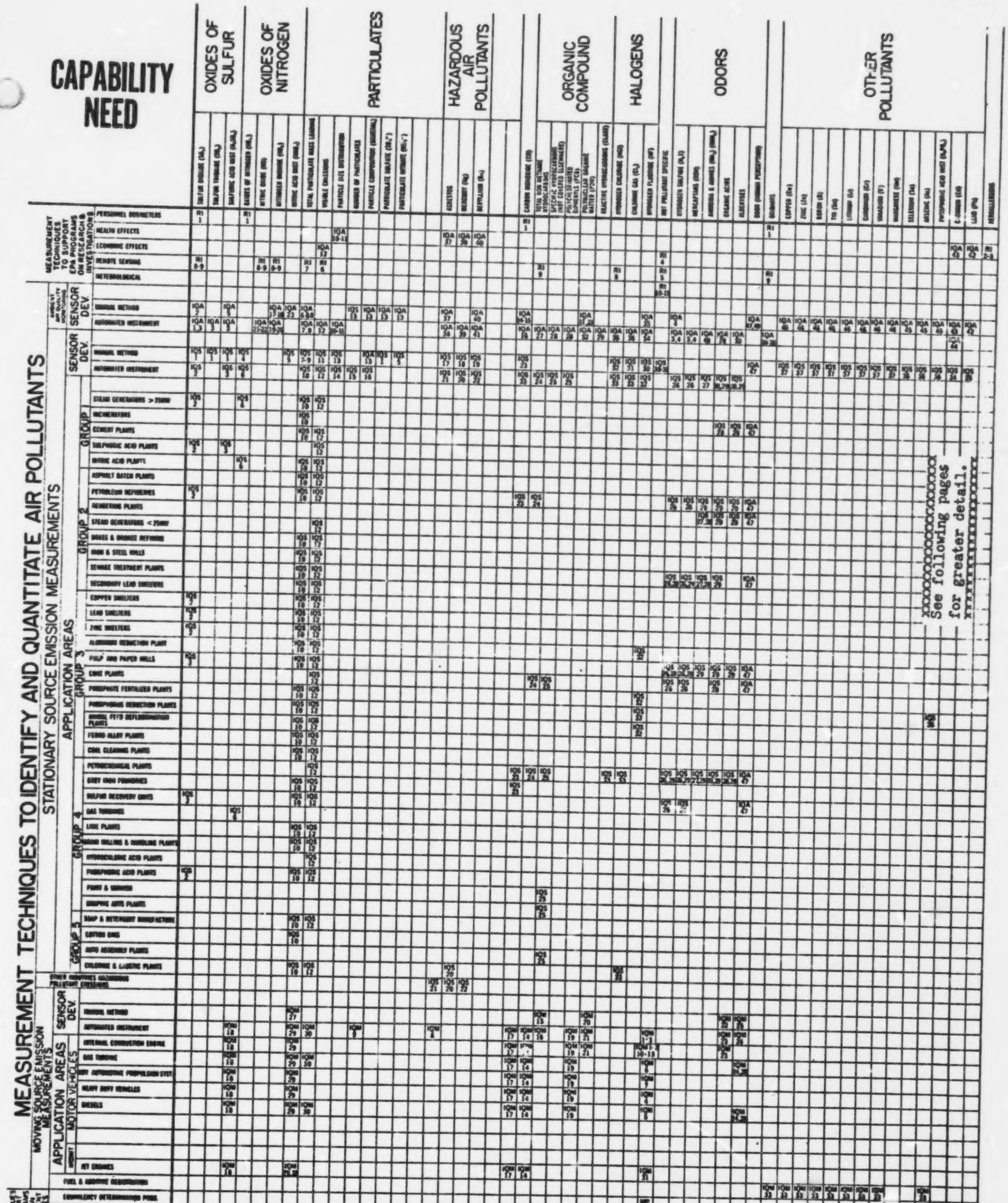
CAPABILITY NEED
MEASUREMENT TECHNIQUES TO IDENTIFY AND QUANTITATE AIR POLLUTANTS
OXIDES OF SULFUR
OXIDES OF NITROGEN
PARTICULATES
HAZARDOUS AIR POLLUTANTS
ORGANIC COMPOUND
HALOGENS
ODORS
OTHER POLLUTANTS
MEASUREMENT TECHNIQUES TO SUPPORT EPA PROGRAMS ON RESEARCH & INVESTIGATIONS
PERSONNEL DOSIMETERS
HEALTH EFFECTS
ECONOMIC EFFECTS
REMOTE SENSING
METEOROLOGICAL
AMBIENT AIR QUALITY MONITORING
SENSOR DEV.
MANUAL METHOD
AUTOMATED INSTRUMENT
STATIONARY SOURCE EMISSION MEASUREMENTS
APPLICATION AREAS
GROUP 1
STEAM GENERATORS > 25MW
INCINERATORS
CEMENT PLANTS
SULPHURIC ACID PLANTS
NITRIC ACID PLANTS
GROUP 2
GROUP 3
GROUP 4
GROUP 5
MOVING SOURCE EMISSION MEASUREMENTS
MOTOR VEHICLES
JET ENGINES
MEAS. TECHNIQUES TO SUPPORT EPA PROGRAMS TO MAINTAIN MEASUREMENT CAPABILITIES
QUALITY CONTROL PROG.
CALIBRATION GASES

See following pages for greater detail.

MEASUREMENT TECHNIQUES TO IDENTIFY AND QUANTITATE A

MEA TECHNIQUES TO SUPPORT EPA PROGRAMS TO MAINTAIN MEASUREMENT CAPABILITIES					MOVING SOURCE EMISSION MEASUREMENTS													STATIONARY SOURCE EMISSION MEASUREME																													
QUALITY CONTROL PROG.					APPLICATION AREAS									SENSOR DEV.				APPLICATION AREAS																													
					AIRCRAFT		MOTOR VEHICLES											GROUP 5				GROUP 4										GROUP 3											GROUP				
	USER PERFORMANCE LEVEL TESTING	CALIBRATION GASES	EQUIVALENCY DETERMINATION PROG.	FUEL & ADDITIVE REGISTRATION	JET ENGINES				DIESELS	HEAVY DUTY VEHICLES	NEW AUTOMOTIVE PROPULSION SYST.	GAS TURBINE	INTERNAL COMBUSTION ENGINE	AUTOMATED INSTRUMENT	MANUAL METHOD		OTHER INDUSTRIES HAZARDOUS POLLUTANT EMISSIONS	CHLORINE & CAUSTIC PLANTS	AUTO ASSEMBLY PLANTS	COTTON GINS	SOAP & DETERGENT MANUFACTURE	GRAPHIC ARTS PLANTS	PAINT & VARNISH	PHOSPHORIC ACID PLANTS	HYDROCHLORIC ACID PLANTS	GRAIN MILLING & HANDLING PLANTS	LIME PLANTS	GAS TURBINES	SULFUR RECOVERY UNITS	GREY IRON FOUNDRIES	PETROCHEMICAL PLANTS	COAL CLEANING PLANTS	FERRO ALLOY PLANTS	ANIMAL FEED DEFLUORINATION PLANTS	PHOSPHORUS REDUCTION PLANTS	PHOSPHATE FERTILIZER PLANTS	COKE PLANTS	PULP AND PAPER MILLS	ALUMINUM REDUCTION PLANT	ZINC SMELTERS	LEAD SMELTERS	COPPER SMELTERS	SECONDARY LEAD SMELTERS	SEWAGE TREATMENT PLANTS	IRON & STEEL MILLS	BRASS & BRONZE REFINING	STEAM GENERATORS <250M
		MP 2																						IQS 2					IQS 2									IQS 2		IQS 2	IQS 2	IQS 2					
		MP 2			IQM 18				IQM 18	IQM 18	IQM 18	IQM 18	IQM 18	IQM 18														IQS 6																			
		MP 2																																													
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									IQM 30			IQM 30		IQM 30				IQS 12			IQS 12			IQS 12	IQS 12	IQS 12	IQS 12		IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	12
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		MP 2			IQM 14				IQM 14	IQM 14	IQM 14	IQM 14	IQM 14	IQM 14																	IQS 24						IQS 24										
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DENTIFY AND QUANTITATE AIR POLLUTANTS

TIONARY SOURCE EMISSION MEASUREMENTS																														AMBIENT AIR QUALITY MONITORING			MEASUREMENT TECHNIQUES TO SUPPORT EPA PROGRAMS ON RESEARCH & INVESTIGATIONS						CAPABILITY NEED
APPLICATION AREAS																											SENSOR DEV.			SENSOR DEV.									
		GROUP 3											GROUP 2								GROUP 1																		
GREY IRON FOUNDRIES	PETROCHEMICAL PLANTS	COAL CLEANING PLANTS	FERRO ALLOY PLANTS	ANIMAL FEED DEFLUORINATION PLANTS	PHOSPHORUS REDUCTION PLANTS	PHOSPHATE FERTILIZER PLANTS	COKE PLANTS	PULP AND PAPER MILLS	ALUMINUM REDUCTION PLANT	ZINC SMELTERS	LEAD SMELTERS	COPPER SMELTERS	SECONDARY LEAD SMELTERS	SEWAGE TREATMENT PLANTS	IRON & STEEL MILLS	BRASS & BRONZE REFINING	STEAM GENERATORS < 25MW	RENDERING PLANTS	PETROLEUM REFINERIES	ASPHALT BATCH PLANTS	NITRIC ACID PLANTS	SULPHURIC ACID PLANTS	CEMENT PLANTS	INCINERATORS	STEAM GENERATORS > 25MW		AUTOMATED INSTRUMENT	MANUAL METHOD		AUTOMATED INSTRUMENT	MANUAL METHOD		METEOROLOGICAL	REMOTE SENSING	ECONOMIC EFFECTS	HEALTH EFFECTS	PERSONNEL DOSIMETERS		
								IQS 2		IQS 2	IQS 2	IQS 2							IQS 2			IQS 2			IQS 2		IQS 2	IQS 1		IQA 1,3	IQA 2			RI 8-9			RI 1	SULFUR DIOXIDE (SO_2)	OXIDES OF SULFUR
																												IQS 1		IQA 3								SULFUR TRIOXIDE (SO_3)	
																						IQS 3					IQS 3	IQS 1		IQA 3	IQA 5							SULFURIC ACID MIST (H_2SO_4)	
																					IQS 6				IQS 6		IQS 6	IQS 4									RI 1	OXIDES OF NITROGEN (NO_x)	OXIDES OF NITROGEN
																														IQA 21-22				RI 8-9				NITRIC OXIDE (NO)	
																														IQA 19-20	IQA 17-18			RI 8-9				NITROGEN DIOXIDE (NO_2)	
																												IQS 5			IQA 23							NITRIC ACID MIST (HNO_3)	
IQS 10		IQS 10	IQS 10	IQS 10	IQS 10	IQS 10		IQS 10	IQS 10	IQS 10	IQS 10	IQS 10	IQS 10	IQS 10	IQS 10	IQS 10			IQS 10	IQS 10	IQS 10		IQS 10	IQS 10	IQS 10		IQS 10	IQS 7-9		IQA 7,9	IQA 6&8			RI 7				TOTAL PARTICULATE MASS LOADING	PARTICULATES
IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12	IQS 12		IQS 12	IQS 12	IQS 12	IQS 12	IQS 12		IQS 12		IQS 12	IQS 11		IQA 12				RI 6	IQA 12			VISIBLE EMISSIONS	
																											IQS 14	IQS 13		IQA 10-11						IQA 10-11		PARTICLE SIZE DISTRIBUTION	
																											IQS 15				IQS 15							NUMBER OF PARTICULATES	
																											IQS 16	IQA 13			IQA 13							PARTICLE COMPOSITION (GENERAL)	
																												IQS 1			IQA 13							PARTICULATE SULFATE ($SO_4^=$)	
																												IQS 5			IQA 13							PARTICULATE NITRATE (NO_3^-)	
																											IQS 21	IQS 17		IQA 38	IQA 37					IQA 37		ASBESTOS	HAZARDOUS AIR POLLUTANTS
																											IQS 20	IQS 18		IQA 39						IQA 39		MERCURY (Hg)	
																											IQS 22	IQS 19		IQA 41	IQA 40					IQA 40		BERYLLIUM (Be)	
IQS [illegible]	IQS 23																		IQS 23								IQS 23	IQS 23		IQA 16	IQA 14-15						RI 1	CARBON MONOXIDE (CO)	
	IQS 24						IQS 24												IQS 24								IQS 24			IQA 27				RI 9				TOTAL NON-METHANE HYDROCARBONS	ORGANIC COMPOUND
	IQS 25						IQS 25																				IQS 25			IQA 28								SPECIFIC HYDROCARBONS (NOT COVERED ELSEWHERE)	
																											IQS 25			IQA 28								POLYCHLORINATED BIPHENYLS (PCB)	
																														IQA 32	IQA 31,33							POLYNUCLEAR ORGANIC MATTER (POM)	
																														IQA 29								REACTIVE HYDROCARBONS (CLASS)	
	IQS 33																										IQS 33	IQS 32		IQA 36				RI 8				HYDROGEN CHLORIDE (HCl)	HALOGENS
	IQS 33																										IQS 33	IQS 31		IQA 36								CHLORINE GAS (Cl_2)	
				IQS 32	IQS 32	IQS 32			IQS 32																		IQS 32	IQS 30		IQA 34	IQA 35							HYDROGEN FLUORIDE (HF)	
																												IQS 36-38					RI 10-13	RI 5	RI 4			NOT POLLUTANT SPECIFIC	
	IQS 26,29						IQS 26	IQS 26,29						IQS 26,29					IQS 26								IQS 26			IQA 3,4	IQA 4							HYDROGEN SULFIDE (H_2S)	ODORS
	IQS 26,29						IQS 26	IQS 26,29						IQS 26,29					IQS 26								IQS 26			IQA 3,4								MERCAPTANS (RSH)	
	IQS 27,29							IQS 29						IQS 27,29				IQS 27,29	IQS 29								IQS 27			IQA 46								AMMONIA & AMINES (NH_3) (RNH_2)	
	IQS 28,29						IQS 28	IQS 29						IQS 29				IQS 29	IQS 29					IQS 28			IQS 28,29			IQA 28								ORGANIC ACIDS	
	IQS 28,29							IQS 29										IQS 29	IQS 29					IQS 29			IQS 28,29			IQA 30								ALDEHYDES	
	IQA 47						IQA 47	IQA 47						IQA 47				IQA 47	IQA 47					IQA 47				IQA 47			IQA 47,48							ODOR (HUMAN PERCEPTION)	
																														IQA 24-26				RI 9			RI 1	OXIDANTS	
																												IQS 37			IQA 46							COPPER (Cu)	OTHER POLLUTANTS
																												IQS 37			IQA 46							ZINC (Zn)	
																												IQS 37			IQA 46							BORON (B)	
																												IQS 37			IQA 46							TIN (Sn)	
																												IQS 37			IQA 46							LITHIUM (Li)	
																												IQS 37			IQA 46							CHROMIUM (Cr)	
																												IQS 37			IQA 46							VANADIUM (V)	
																												IQS 37			IQA 46							MANGANESE (Mn)	
																												IQS 36			IQA 45							SELENIUM (Se)	
																												IQS 36			IQA 45							ARSENIC (As)	
					IQS 36																							IQS 36			IQA 45							PHOSPHORIC ACID MIST (H_3PO_4)	
																												IQS 34		IQA 44	IQA 43					IQA 43		CADMIUM (Cd)	
																												IQS 35			IQA 42					IQA 42		LEAD (Pb)	
																																				RI 2-3		AEROALLERGENS	

B